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CLIMATIC CHANGES EXPOSE HONEYBEE COLONIES TO ERADICATION DUE TO INCREASING FEROCITY OF ATTACKING PREDATOR, ORIENTAL HORNET *VESPA ORIENTALIS* L, IN NORTH SINAI REGION

Mahfouz, H. M.[(1)*], Abd Al-Fattah, M. A.[(2)]

[(1)] Plant Production Dept., Fac. of Environ. Agric. Sci., Arish Univ., 45511, Egypt

[(2)] Dept. of Economic Entomology & Pesticides, Fac. of Agric., Cairo University, Egypt

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ABSTRACT: The climatic changes during the last two decades enhanced the invasion and establishment of *Vespa orientalis* in North Sinai governorate. This study was carried out using the modified hive trap in honeybee apiary at Al-Arish province, to monitor the seasonal abundance, diurnal activity and negative impact of *Vespa orientalis* as predartor on bee colonies for two successive years (2019 & 2020). The relationships between optimum air temperatures and relative humidity and the dynamic fluctuations of hornet are taken in consideration. The results showed that there are increase in temperature and RH by means of 4.7C° and 2.9 % after thirteen years of the first record of this hornet in North Sinai region. High significant and significant positive correlations were found between the population dynamic of oriental hornet and both temperature and RH, respectively. Few individuals of hornet start to appear from March till May, then low population was observed in June followed by gradual increase from the first week of July up to the end of October. In the two studied years, the highest numbers of hornet were recorded during the first and fourth weeks of September. The wasp tends to disappear from the second fortnight of November. For the diurnal activity of hornet, the highest significant numbers were caught during the periods from 9am till 12 pm and from 12 pm till 3pm in July and August, meanwhile the period before 9 am and after 3pm recorded the lowest numbers of hornet. However, during September and October the highest trapped numbers was alternate toward the second half of the daytime, (12pm to 6pm). The effects of hornet attacking pressure on honeybee colonies start to appear from the 4th week of August in 2019 and from the 2nd week of September in 2020. The highest eradication percentages of bee colonies were in October (25.3% in 2019) and November (19.1% in 2020). The total wiped out percentages of attacked colonies were 57.3 % and 44.1 % during the two years, respectively. It concluded that the future sustainable beekeeping in North Sinai under a great thereat due to the predator of *V. orientalis* and the efforts must be cooperative to introduce an Integrated Management Control Program included the modified hive traps.

Key words: Climatic change, *V. orientalis* , honeybee *A. mellifera* colonies, seasonal abundance, diurnal activity, eradication, North Sinai.

INTRODUCTION

Colonies of honeybees play an important role in the pollination of more than 85 % of worldwide crops, (Abrol, 2012 and Bista and Lakhey, 2017). However, they always expose to undesirable stresses affect their potential and productivity as pollinators and their output bee products as well. Natural enemies which extended from microorganisms to large mammals are presented a major sector of those stresses, (Akre and Mayer, 1994). Vespine wasps are social hymenopterous insects to be considered primary pests to honeybee colonies as a rich source of carbohydrates and animal protein necessary to feed their brood, (Matsuura & Yamane, 1990; Beggs, *et al.*, 2011; Sharma & Mattu, 2014). So, they are globally known as dangerous enemies causing serious impacts result in wiped out the attacked honeybee colonies, (Moller, 1996; Ranabhat, & Tamrakar, 2008; Abd Al-Fattah & Ibrahim, 2009; Monceau *et al*., 2014a; Bista and Lakhey, 2017; Bista *et*

*Corresponding author: Hatemmahfouz2@gmail.com

al., 2020 and Cobey, *et al*., 2020). These wasps have a potential to invade new regions and adapting with a wide range of environmental conditions, (Edwards, 1980; Chapman & Bourke, 2001; Mathews *et al*., 2000; Kasper *et al*., 2008; Villemant *et al.*, 2006 & 2011; Monceau *et al.*, 2017). The yellow-banded brown wasp which known as oriental hornet, (*Vespa orientalis* L.) is one of twenty three hornet species that primarily presents in Asia, (Singh, 1962; Ishay, 1964; Ishay, *et al.*, 1967; Adlakha *et al*., 1975; Abrol, 1994; Akre, *et al*., 1994; Glaiim, 2009; Aryal, *et al*., 2015; Kumar, *et al*., 2015; Al- Heyari, *et al.*, 2016 and Bista & Lakhey, 2017), Africa (Sharkawi, 1964 and Archer, 2012) and South Europe, (Darchen, 1964; Edwards, 1980; Carpenter & Kojima, 1997; Monceau *et al.*, 2014b).

However, the noticeable changes in global climatic conditions during the last few decades enhanced its invasion potential to new regions such as Italy, (Bressi *et al*., 2019), Central Europe (Ćetković, 2002; Dvořák & Roberts, 2006; Dvořák, *et al*., 2012), on Metropolitan France in the city of Marseille,(Gereys *et. al*., 2021),on the Iberica Peninsula (Hernández *et al*., 2013), Bangladesh, (Kumar *et al*., 2015), in Chile, (Rios, *et al*., 2020) reached Spain(Sánchez, *et al*.,2019), in the United States, (Smith-Pardo *et al*.,2020), in Romania (Zachi & Ruicănescu, 2021) in Mexico (Dvořák, 2006) and in China (Archer,1998).

In Egypt, the oriental hornet is native to all regions located alongside the delta of river Nile (Sharkawi, 1964; Wafa, *et al*., 1968&1969; Hussein and Shoreit, 2000; Sweelam *et al*., 2019). But, recently it invaded great areas of semi-arid regions such as Suez Canal area, (Sallam,1992) and El-Mullack district in Sharkia governorate, (Khater *et al*., 2001). In regard to Sinai Province as semi- arid region and represents one-sixth of the area of Egypt, the hornet was firstly registered during 2002 in South Sinai associated with Bedouin settlements in the southwestern part of the St Katherine protectorate in abundance from April to November, peaking during August and disappearing between December and March, ((Abdel-Ghany, *et al*., 2008). Reversely in North Sinai, El- Bassiony, *et al*. (2010) registered neglect numbers of this wasp in apiaries of Al-Arish and Rafah during seasons of 2006 and 2007. But beekeepers of North Sinai were strongly suffered from the serious injuries that caused from hornets to their colonies during the last five years. Hence, the aim of this proposal is to monitoring both diurnal activity and seasonal variations of hornet population dynamic and predation rates along with weather parameters in order to be helpful in developing sustainable management plans against the hornet in honeybee apiaries.

MATERIALS AND METHODS

Study location:

This work was carried out for two successive years, (2019 and 2020) at a privet apiary about 3 km. apart from Al-Arish City, Al-Arish province (Elevation: 18.78 masl; Latitude: 31° 07' 53.72" N and Longitude: 33° 47' 54.38" E) of North Sinai governorate.

Monthly and weekly population dynamic of oriental hornet:

The weekly population dynamic of oriental hornet (*Vespa orientalis* L.) around honeybee colonies at Al-Arish province during two successive years (2019 and 2020) were determined using the modified hive trap (Ibrahim, 2009 and Mazeed & Abd Al-Fattah, 2019). Each trap was designed as a cage from wooden bars and wire screen in diameters of 30 x 40 x 75 cm. The base of the cage covered with wire screen which had an upward open on the shape of a cone to allow the hornet to enter but not escape. This cage constructed upon wire cone fixed on the top of Langstroth empty hive hold over hive stand. Each trap provided with three combs of unripens honey or empty wax combs with sugar syrup. Three traps were randomly distributed within the site of the experimental apiary. These traps were weekly re-baited after collected and counted the caught hornet individuals from the beginning of June until the end of November through the two years of study. Sweep net was used in catching hornet

individuals daily at three hours intervals during March, April and May of each year.

Determination of oriental hornet diurnal activity around honeybee colonies:

The hornet diurnal fluctuation around the honeybee colonies was determined through the clear and high activity of its individuals from July until November of the two study years. Two fortnights were evaluated, for each month, the first occurred in the first week and the second ones was during the third week of the same month. Four collections of the caught individuals' hornet by the mentioned trap were counted in each fortnight at three hours intervals for one day. These evaluations were at hours of 900, 1200, 1500 and 1800. It is noteworthy that the last collection (1800) was done during July, August, September and before sun set (1650 hr– 1750 hr) during October and November.

The serious impacts of oriental hornet against honeybee colonies :

The number of eradicated honey bee colonies during the period from beginning of July to the end of November was recorded weekly and calculated as a percentage of the origin number of presented colonies before hornet appear for each year (75 and 68 colonies were originated in 2019 and 2020, respectively). The investigated colonies were nearly similar in their strength (each had from 7-10 combs covered with bees and 4-7 brood combs) and received the same manipulations of feeding and parasitic mite, *Varroa destructor* control by Apistan strips from beginning of September.

Meteorological parameters:

The meteorological data (averages of optimum air temperatures in C° and relative humidity percentages at 2 meters above the earth surface) were obtained from the Desert Research Center in North Sinai. Two sets of years were took in consideration, the first included years of 2006 and 2007 where the first research indicated that no threat from oriental hornet at Al-Arish, (El-bassiony *et al*., 2010) and the second included years of this work (2019 and 2020) where the outbreak of hornet were observed.

Statistical analysis :

Data of all treatments were analyzed in a randomized complete block design (ANOVA) by MSTAT-C version 1.41 (Sendecor and Cochran, 1980) and using graph pad prisma version 3.03 for windows, software. All means were compared by Duncan's Multiple Range test, (DMRT) at level 0.05 of probability.

RESULTS AND DISCUSSION

1- Change in climatic factors between 2006 and 2020 in North Sinai region:

Data in Tables (1 &3) appear the range and mean values of optimum temperature and relative humidity percentages during seasons of 2019 and 2020 in comparison with those degrees in 2006 and 2007 at Al-Arish province. It is clear that after thirteen years ago the optimum air temperature increased by 4.7 C° and 5.0 C° during winter and spring seasons of 2019 and 2020 than 2006 and 2007, respectively. Those increases in temperature were 4.5 C° and 4.6 C° during the period of summer and autumn of the mentioned years, respectively. It is ,also, obvious from data that the thermal range of the changeable values during winter- spring period,(1.2 – 8.7 C° and 2.7 – 8.4 C°) were narrow than that noticed during summer – autumn period,(0.6 - 8.4 C° and 0.0 - 9.8 C°) of the two comparative sets, respectively. The general mean of increasing in optimum temperature after thirteen years ago(between 2006 – 2020) was 4.7 C° as shown in Table (1). Likewise, the general mean increase in relative humidity was 2.9 % over the two comparison sets of years with a noticeable annually seasonal fluctuation as illustrated in Fig. (1).

The obtained results are agreement with the findings of Dadamouny and Schnittler (2016) about the rapid climate change in the Sinai Peninsula. They show a clear tendency towards decreasing rainfall and increasing average temperatures when their data from 1970 to 2014

were analyzed. They concluded that if this tendency continues, the population dynamics of many plant and animal species will be negatively affected especially in the coastal regions among them Al-Arish region. Also, both Lelieveld, *et al*. (2016) and Bucchignani, *et al*. (2018) proved that climate change projections for the Middle East- North Africa show a significant warming over the whole area considered at the end of the 21st century.

Table (1): Mean of changeable rate in air temperature (C°) and relative humidity after thirteen years ago at Al - Arish province during 2019 and 2020

Weather factor	Winter - Spring		Summer - Autumn		Mean / year
	Range	Mean	Range	Mean	
Temperature					
2006	13.3 - 21.3	16.2	19.0 - 26.6	24.0	20.1
2019	18.1 - 23.4	20.9	24.9 - 32.3	28.5	24.7
Value of change	1.2 - 8.7	4.7	0.6 - 8.4	4.5	4.6
2007	13.7 - 21.0	17.13	18.9 - 30.0	25.2	21.2
2020	19.3 - 24.5	22.13	26.3 - 33.7	29.8	26.0
Value of change	2.7 - 8.4	5.0	0.0 - 9.8	4.6	4.8
Mean of changeable value		4.85		4.55	4.7
Relative humidity					
2006	66.0 - 72.0	69.5	70.0 - 73.0	71.0	70.4
2019	73.5 - 83.0	75.9	73.0 - 82.5	78.9	77.4
Value of change	3.5 - 12.0	6.4	2.0 - 11.0	7.6	7.0
2007	74.6 - 82.8	79.9	77.1 - 84.9	81.9	80.9
2020	76.0 - 85.0	78.3	75.0 - 83.0	81.0	79.7
Value of change	(-4.3) - 3.4	(- 1.6)	(-8.4) - 5.9	(- 0.9)	(- 1.3)
Mean of changeable value		2.5		3.4	2.9

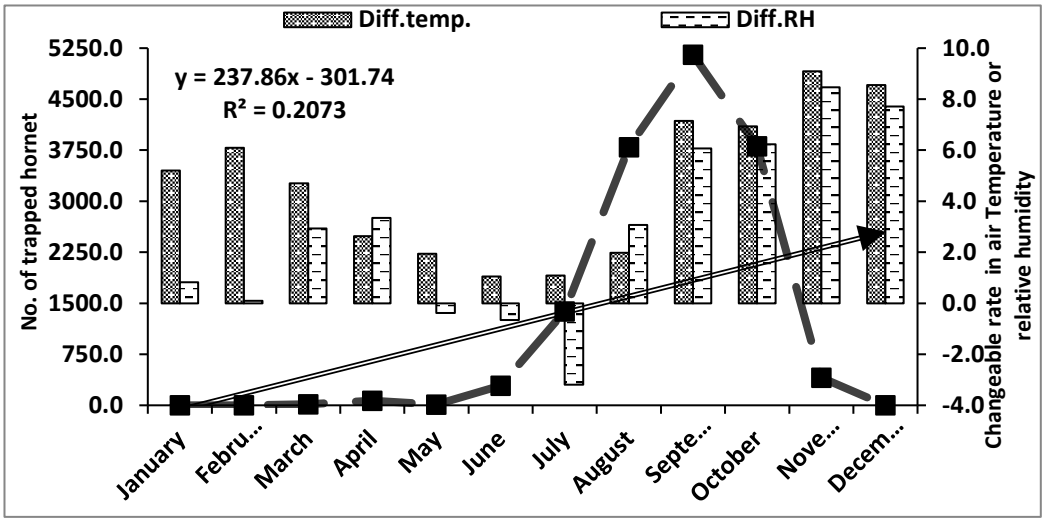

Fig. (1): Relationships between the changeable values in weather temperature and relative humidity throughout thirteen years (from 2006 to 2020) and the population dynamic of oriental hornet around honeybee colonies at Al-Arish province

2- Seasonal population dynamic of oriental hornet:

A total of 29864.3 individual hornet / trap were counted, 16202.0 during 2019 year and 13662.3 during 2020 year. The hornet disappeared from the second fortnight of November until the third week of March through the two studied years as shown in Table (2) and Fig. (1). The hornet mated queens started to appear in scarce numbers during the fourth week of March and relatively raised in April then sharply decreased again during May. A noticeable presence of hornet offspring hovering around honeybee colonies and inter the traps during June month. From the beginning of July the numbers of hornet were exponentially increased throughout the followed months to reach the highest peak in the first (2035.8 individuals/ trap for 2019) and the fourth weeks (1440.9 individuals/ trap for 2020) of September, Table (2). On the other hand, little or no numbers of hornet caught by the traps during the third or fourth week of November for the two years respectively, Table (2).

A randomized complete block design of hornet population from July to November of the two observed years showed that the differences were significant between years, ($F_{1,119} = 51.9403$, $P < 0.0187$) and highly significant between months, ($F_{4,119} = 167.2372$, $P < 0.0000$) as reveal in Table (2). The highest mean numbers of caught hornet per trap for the two years was recorded during September (5502.8 hornet/trap and 4805.3 hornet/trap, respectively). The trapped hornets during October (3782.2 hornet / trap and 3831.4 hornet / trap, respectively) were higher than those recorded in August (4628.5 and 2959.5 hornet / trap, respectively) with insignificant difference between them.

The caught hornets during July (1519.1 and 1246.8 hornet / trap) were significantly less than those recorded in the previous months. The least trapped numbers of hornet were counted in November, (301.4 and 508.0 hornet / trap, respectively) as shown in Table (2) and Fig . (2).

Table (2): Mean numbers of monthly variation in trapped oriental hornet within apiary at Al-Arish during the months of two successive years (2019 and 2020)

Month	Mean numbers of caught hornet / trap					
	2019	± SD	2020	± SD	Mean / Month	± SD
January	0.00	0.00	0.00	0.00	0.00	0.00
February	0.00	0.00	0.00	0.00	0.00	0.00
March	22.00	7.00	14.67	2.08	18.00	6.12
April	64.33	17.50	73.67	13.05	68.50	14.72
May	15.33	5.03	10.67	6.11	12.50	5.62
June	368.30	65.01	215.70	29.50	291.00	95.03
July	1519.10	327.93	1246.20	40.10	1382.65	96.48
August	4628.50	513.50	2959.20	110.40	3793.85	590.19
September	5502.80	423.31	4805.40	853.61	5154.10	246.58
October	3782.20	243.96	3831.50	347.52	3806.80	17.43
November	301.40	112.28	508.00	161.18	404.70	73.04
December	0.00	0.00	0.00	0.00	0.00	0.00
Total	16203.97		13665.00		14932.10	
Mean	1800.44	739.50	1518.33	619.64	1659.12	675.37

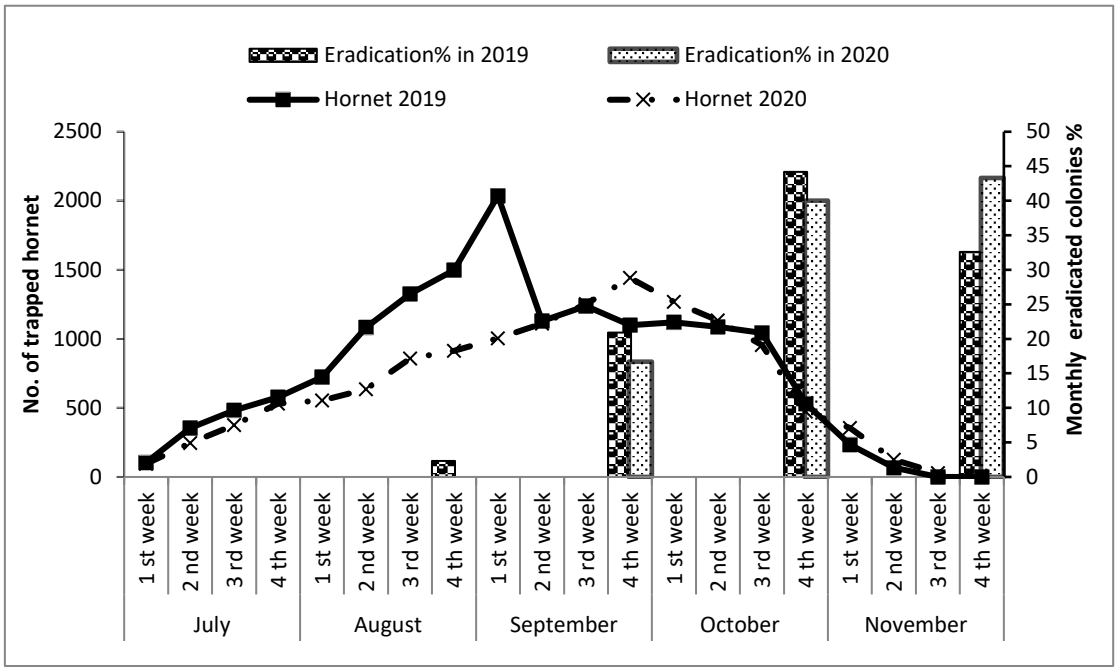

Fig. (2): Weekly numbers of trapped hornet and percentages of monthly eradicated colonies from July to November of years 2019 and 2020 at Al-Arish province

Table (3): Correlation and regression coefficients between means ofoptimum temperatures & humidity and monthly fluctuations in oriental hornet population at Al - Arish during two years (2019 & 2020).

Weather parameter	2019		2020	
	Cor. Coeff. (R^2)	Reg. Coeff. (b)	Cor. Coeff. (R^2)	Reg.Coeff. (b)
Optim. temperature	0.82**	378.99	0.84**	318.94
Relative humidity	0.58*	307.16	0.60*	276.38
df = 10, P = 0.576 at 5% probability and P= 0.708 at 1% probability				

The differences between both years or months concerning the numbers of trapped hornet may be attribute to the effect of traps during the first year especially in catching the hornet females destined to become queens during October and November (Abd Al-Fattah & Ibrahim, 2009; Abd El-Kareim, *et al*., 2013; Monceau, *et al.*, 2014a and Monceau & Thiery, 2017). Therefore, few numbers of wintered hornet mated queens could start their new nests in the followed season and this reflects on the total offspring production and speed of nest development. So, in the second season of this work the highest population of trapped hornet was delayed to the fourth week of September, (Table 4 & Fig. 2). Statistical analysis show that there were highly significant differences for the interactions between years and months, ($F_{4,119} = 6.1859$, $P < 0.0033$) and between months and weeks, ($F_{12,119} = 11.1372$, $P < 0.0000$).

Many researchers proved that population of hornet workers was fluctuated through September and October according to various reasons such as location, biological status of the nest, feeding demands and climatic conditions as Shoreit,1998; Ahmed, 1999; Abou El-Enain, 1999; Khater, *et al*., 2001; El-Sherif, 2003; Gomaa & Abd El-wahab,2006; Hussain, *et al*., 2009; Ahmed, 2011; Khodairy and Awad, 2013;

Abd Al-Fattah, *et al*. 2014 and Fouad, *et al*., 2021. They also agreed that maximum activity of predator wasp was recorded between September and October, thereafter decreasing trend was up to end from the second fortnight of November to the first fortnight of December.

It is noteworthy that the preceded studies on the seasonal variation of oriental hornet in the same region observed negligible individuals, (with a total ranged from 28 to 52 hornets) concentrated through April, September, October and November of two studied years, (2006 &2007) as reported by El- Bassiony, *et al*. (2010). The corresponding range of optimum temperatures was from 13.3 to 30.0 C° of the two mentioned years. However, in the recent work this range raised by a mean value of 4.7 C° (Table 1). This increase in temperature is more suitable for hornet queens to early exit from hibernation and start in constructing new nest and offer all brood care that resulted in speed emergence of new generations during spring and still continue toward Summer and Autumn. This explanation confirmed by Ibrahim & mazeed, (1967) who found that warm nights lead to great activity of oriental hornet through the following days as noticed by the large numbers of the trapped hornets. So, this research found a significant positive correlation between the degrees of temperature and abundance of hornet throughout the months of the year as shown in Table (3) and (Fig. 1). In this manner, Khater *et al*. (2001) at El – Mullak, Ismailia governorate, found a positive correlation between the daily mean temperature and the monthly trapped hornets, while this correlation was slightly negative with relative humidity. Abdel – Gahny *et al*. (2008) in South Sinai, mentioned that *Vespa orientalis* was active and abundant from April to November when the average temperature ranged from 23 – 38 C°. It is absent in Winter and did not observe at temperatures below 16 C°. Also, Volynchik, *et. al*. (2008) found a positive correlation between *V. orientalis* flight activity and both UVB radiation and temperature. Volov, *et al*. (2021) reported that the environmental temperature was shown to affect the hornet colonies ' thermal environments as tested *V. orientalis* from two extreme climatic zones: Mediterranean high elevation and hot arid desert. Nonetheless, the hornets maintained their colony temperature within a narrow range and this refect on the active population outside the nest.

Table (4): Mean numbers of weekly and monthly trapped oriental hornet within apiary in Al- Arish from July to November of two successive years (2019 and 2020)

Month	1st week	± SD	2nd week	± SD	3rd week	± SD	4th week	± SD	Total	Mean/ month	± SD
2019 (75 colonies)											
July	104.7b	77.4	354.2ab	58.2	482.2a	38.4	578.0a	265.6	1519.1	379.8C	205.0
Aug.	723.3c	445.3	1082.7b	106.9	1325ab	175.0	1497a	306.6	4628.5	1157.1B	335.5
Sept.	2035.8a	159.7	1129.6b	74.3	1237.4b	229.9	1100b	93.5	5502.8	1375.7A	444.0
Oct.	1120.0a	177.7	1087.6a	205.5	1043.6a	184.2	531b	19.4	3782.2	945.6B	278.1
Nov.	233.3a	98.5	68.1a	16.8	0.0a	0.0	0.0a	0.0	301.4	75.4D	110.1
2020 (68 colonies)											
July	95.7b	7.2	245.3ab	10.4	376.2ab	2.3	529.5a	36.8	1246.8	311.7C	185.0
Aug.	554.9b	7.0	634.3ab	67.5	850.0ab	77.0	912.3a	36.8	2959.5	739.9B	172.3
Sept.	1002.9b	191.6	1110 ab	233.1	1252ab	26.7	1441a	574.6	4805.3	1201.3A	189.4
Oct.	1268.6a	289.2	1135ab	356.6	954.4ab	204.8	473.7c	24.6	3831.4	957.9B	347.5
Nov.	355.0a	53.5	125.0a	52.3	28.0a	28.8	0.0a	0.0	508.0	127.0D	161.2
Mean/ week/year	749.4a	617.4	697.2a	459.4	755.7a	500.5	706.3a	526.3	2908.5	727.1	472.5

Means in the same column or row with the same capital letter or the same capital letter do not significant differ according to DMRT at 5% probability.

In contrast to previous studies was recorded by several investigators such as Khater, *et al*. (2001), Hussien *et al*. (2009), Ahmed (2011) and Taha (2014) the relative humidity percentages in the present work increased between 2006 and 2020 by a mean value of 2.9 % (Table 1) and revealed significant positive impacts on the population dynamic of hornets throughout the two years at Al-Arish as shown in Table (3). This may be due to the moderate portions of humidity in the semi-arid regions help hornets in digging operations and enlarge the nest in the hard areas. These findings are in accordance with those observed in sub humid environment of Pakistan by Islam *et al*. (2015). They registered a positive correlation between relative humidity and seasonal abundance of *V. orientalis* where the highest number of captured hornets was observed during October and September (193 and 139) with an average temperature and relative humidity (29.11°C, 68.82% and 33.04°C, 68.09%, respectively). Veldtman *et al.* (2021) studied the spatio – environmental analysis of *Vespula germanica* (family:Vespidae) that inveded South Africa and generally reported that factors related to moisture stress set the environmental of *V. germanica* landscape distribution and the strong preference of nesting sites related to medium to medium-high summer normalised difference moisture index (NDMI).

3- Seasonal percentages of eradicated colonies by attacks of oriental hornet:

Monthly and weekly numbers and percentages of eradicated colonies due to serious attack during the high sorties of oriental hornets were beginning from August of the two observed years, (Table 5 and Fig. 2). It is appear from results that the serious pressure on honeybee colonies was gradually increased to reach the highest impact in the first (18.6 % for year of 2019) and second, (18.8 % for year of 2020) weeks of November, respectively. The highest destruction in honeybee colonies was occurred in October (44.2%) and November, (40.6 %) while the lowest injury was during August, (2.3 % & 0.0%) for the two years, respectively, (Fig. 2).

The great damage caused by *V. orientalis* and other vespine wasps on honeybee colonies have been noticed either in local or global regions. Adlakha, *et. al*. (1975) in India, recorded 20 – 25 % of bee colonies deserted annually due to predatory activity of hornets. Also, in Japan, Akre and Davis (1978) reported that a group of 30 *V. mandarina* S., was able to kill 25000 out of 30000 bees in three hours. Abd Al-Fattah & Ibrahim (2009) recorded percentages of total wiped out colonies by 50.81% and 38.24% during monitoring the attacking of oriental hornet for two successive years,(2006 & 2007) in Giza region. Also, Abd Al-Fattah, *et al*. (2013) found that the hornet individuals could caught an average of 5166.0 bee workers / colony during September and this figure jumped to 16216.2 bee / colony during October due to the extensive attack on colonies. Villemant *et al*. (2011) found that a huge amount of protein is required to feed the *V. velutina* larvae during the colony's growth, and about one-third to two- third of the hornet's diet obtained from honeybee colonies.

The present study proved that, based on trapped hornets, the predation pressure increased with the progression of the season as reported for *Vespa orientalis* by Ishay *et al*. (1967) and for the yellow- legged hornet, (*Vespa velutina*) in France by Monceau, *et al*. (2013 a&b). Bista, *et al*. (2020) in Nepal, reported that the incidence and predation rates of various species of vespine hornets were low in early Spring and Summer, then gradually increased with the highest peak in October and November. Recently, in Minia region, Fouad, *et. al* (2021) followed the seasonal abundance of oriental hornet, and revealed that *V. orientalis* workers started to appear from July to December with a peak of activity during October. They, also, studied the effect of the predator attack on the average numbers of combs covered with bees of the exhausted colonies at the end of hornet active season and found that the damaged colonies were increased during active months to reach the maximum destruction in October (5 and 4.5 combs in exposed compared to 7.8 and 7.0 combs for un- exposed colonies) of two successive years, respectively.

Table (5): Weekly and monthly numbers and percentages of waiped out colonies under attack of oriental hornet during August to November of two successive years at Al- Arish, North Sinai governorate

Month	1st week		2nd week		3rd week		4th week		Total		Eradication %	± SD
	No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.	(%)		
2019 (75 colonies)												
August	0	0	0	0.0	0	0.0	1	2.3	10	2.3	1.3	1.2
September	1	2.3	2	4.6	2	4.6	4	9.3	9	20.9	12.0	2.9
October	4	9.3	4	9.3	5	11.6	6	9.3	19	44.2	25.3	1.2
November	8	18.6	4	9.3	2	4.6	0.0	0.0	14	32.6	18.7	8.0
Total	13	30.2	10	23.3	9.0	20.9	11.0	25.6	43	100	57.3	4.0
2020 (68 colonies)												
August	0	0.0	0.0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0
September	0	0.0	1.0	3.1	1.0	3.1	5.0	16.7	5.0	16.7	7.4	3.9
October	2	6.3	3.0	9.4	3.0	9.4	12.0	40.0	12.0	40.0	17.6	2.5
November	5	15.6	6.0	18.8	1.0	3.1	13.0	43.3	13.0	43.3	19.1	8.2
Total	7	23.3	10.0	33.3	5.0	16.7	30	100.0	30.0	100.0	44.1	6.9
Mean/year	10	26.7	10.0	33.3	7.0	18.8	37	100.0	36.5	100.0	51.0	4.2
± SD	2.93		2.14		1.67		2.20		6.66		9.1	

4- Diurnal activity of oriental hornet around honeybee colonies:

The results in Tables (6 & 7) show the diurnal fluctuation in numbers of hornet at three hours intervals from July to November of 2019 and 2020. Generally, the individuals of *V. orientalis* showed hovering around honeybee colonies from morning to the sunset. However, few numbers of hornet population appeared in apiary during early morning at 9 a.m. and late afternoon at 6 p.m. of both July and August (Fig. 3&4). The highest attacks of hornet were recorded at 12 a.m. and 3 p.m. for the two previous months. During September of the first year, there were out break in hornet population where a mean of 48.9 hornets / trap caught at 9 a.m. and did not significantly differ than that caught at 12 a.m. (50.5 hornets/trap). Significant high numbers of hornets caught at 3a.m. (66.6 hornets / trap) and 6 p.m. (67.8 hornets / trap) of that month. However, during the second year in spite of the trapped hornets at morning was significantly less than evening the highest activity of hornet was observed at 3p.m. (77.5 hornets / trap) followed by 12a.m. (66.6 hornets / trap) as shown in Table (7) and Fig. (4). Likewise, the diurnal activity of hornet during October of the first year was similar to that noticed during September of the same year. But during October of the second year, the diurnal hornet activity did not differ between hours of the day time (Table 7 and Fig. 4). A sharp decline in hornet population with the beginning of November of the two studied years resulted in low caught individuals at any time of the day.

The above results are in agreement with the findings of many investigators such as (Singh, 1962; Ibrahim & Mazeed, 1967; Sihag, 1992a&b; Ahmed, 1999; Khater *et al*., 2001; Gomaa & Abd El-Wahab, 2006; Abd Al-Fattah and Ibrahim, 2009 and Abd Al-Fattah, *et al*., 2013). They agreed that Oriental hornet, *Vespa orientalis* L. started to visit *Apis mellifera* L. apiaries from June or July and continued up to November. Increasing the population during autumn season might be due to emergence of over wintering graved females which started to increase the population. Abrol (1994) recorded that diurnal activity of oriental wasp showed a peak between 0900 and 1300 hr. Increasing the

activity of hornet after 1000 hr. may be due to increase of sun shine and inconsequently the ray of ultra violet (UV), which used by hornet as source of energy (Ishay, 2004 and Volynchik, *et al*., 2008). Ibrahim (2009) noticed that the highest numbers of hornet attack during August was at 1400 h , during September at 1600 h and during October at 1800 h Abd Al-Fattah, *et al.* (2014) at Giza region recorded a high activity of oriental hornet around honeybee colonies from early morning (7 am) to the sunset with peak concentrated at 1 pm followed by 10 a.m. during September, October and November. El-Boulok *et. al*. (2019) found that the highest numbers of oriental hornet captured by wasp's traps were recorded in October month during the noon period, 12pm – 3pm with an average of 33.15 wasp/trap, followed by November month during the same period, 12pm – 3pm (20.50 wasp/trap). The highest number of wasps captured by the traps was recorded during the period from 12pm – 3pm followed by morning period (9am – 12pm), mean-while the evening period (3pm – 9am of next day) recorded the lowest number of wasps captured by the traps, with significant differences between all the tested periods.

In this respect, many authors explained the increasing activity of workers of *Vespa* and *Vespula* species early in the morning during Autumn season to the urgent need of larvae for food after nocturnal feast, (Edwards, 1980 and Sihag, 1992b) and / or to the fact that removing water in the form of dew is easiest when collected early in the morning, (Perrard, *et al*.,2009). Darchen (1964) noticed that several captive oriental hornet colonies used half of their own larvae to feed adults and the remaining brood rather than live honeybees provided in sufficient amount. Beside, Ishay (1964) and Sharkawy (1964) reported that the highest number of hornet brood within the nest was found during the month of October.

Table (6): Diurnal activity of oriental hornet at three hours intervals,two fortnight/ month, as caught by traps within apiary in Al-Arish from July to November of year 2019

Month\ Time	9 am.	12 am.	3 pm.	5 - 6 pm.	Mean / month ± SD	
July	1.9 Cb	12.4 Cab	23.4 Ca	4.2 Db	10.5 C	9.71
August	15.2 Bc	50.5 Ab	65.3 Aa	15.3 Cb	36.6 B	25.37
September	48.9 Ab	50.3 Ab	66.6 Aa	67.8 Aa	58.4 A	10.18
October	18.9 Bc	34.6 Bb	51.4 Ba	49.8 Ba	38.7 B	15.22
November	2.4 Ca	5.8 Ca	6.4 Da	2.0 Da	4.2 C	2.26
Mean / time	17.5 C*	30.7 B*	42.6 A*	27.8 B*	29.67	
± SD	19.15	20.89	26.72	29.41	22.22	

Means in the same column or row with the same capital letter or the same capital letter do not significant differ according to DMRT at 5% probability.

Table (7): Diurnal activity of oriental hornet at three hours intervals,two fortnight/ month as caught by traps within apiary in Al-Arish from July to November of year 2020

Month\ Time	9 am.	12 am.	3 pm.	5 - 6 pm.	Mean / month ± SD	
July	6.7 Dc	17.8 Cbc	33.7BCa	7.6 Cc	16.7 D	12.33
August	22.7BCb	43.1 Ba	26.0 Cb	23.8 Bb	28.9 C	9.58
September	19.0CDc	66.6 Aa	77.5 Aa	41.8 Ab	51.2 A	26.17
October	36.6 Aa	39.4 Ba	41.6 Ba	36.6 ABa	38.5 B	2.41
November	0.2 Ea	2.9 Da	1.6 Da	0.2 Ca	1.2 E	1.31
Mean / time	17.2 B*	34.0 A*	36.1 A*	22.0 B*	27.30	
± SD	14.07	24.53	27.57	17.97	19.33	

Means in the same column or row with the same capital letter or the same capital letter do not significant differ according to DMRT at 5% probability.

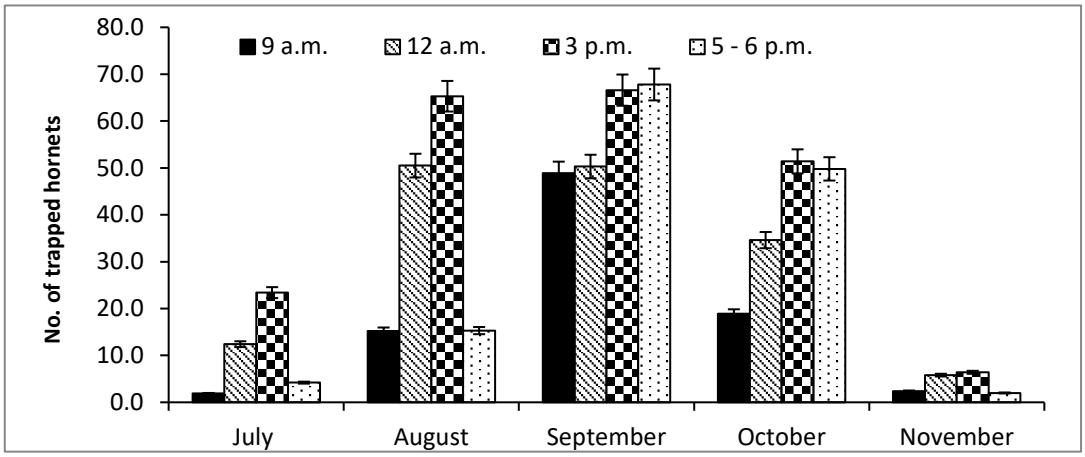

Fig. (3): Diurnal activity at three hours intervals based on the numbers of trapped hornets during the months of July to November, 2019 at Al-Arish province

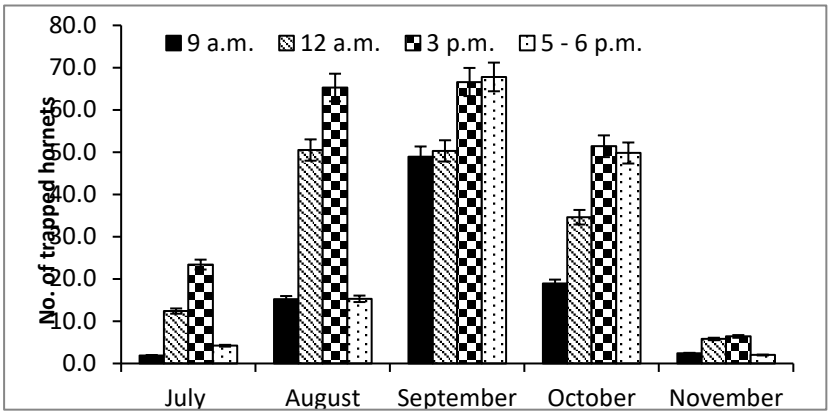

Fig. (4): Diurnal activity at three hours intervals based on the numbers of trapped hornets during the months of July to November, 2020 at Al-Arish province

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تعرض طوائف نحل العسل للإبادة بسبب زيادة شراسة هجوم الدبور الشرقى نتيجة التغيرات المناخية في منطقة شمال سيناء

حاتم محمد محفوظ[١] - محمد عبد الوهاب عبد الفتاح يوسف[٢]

[١] قسم الإنتاج النباتي ، كلية العلوم الزراعية البيئية ، جامعة العريش ، ٤٥٥١١ ، مصر

[٢] قسم الحشرات الاقتصادية – كلية الزراعة – جامعة القاهرة – الجيزة - مصر

الملخص العربي

عززت التغيرات المناخية خلال العقدين الماضيين من غزو وتكاثر الدبور الشرقي في محافظة شمال سيناء. أجريت هذه الدراسة باستخدام مصيدة خلية النحل المعدلة في احد المناحل بمحافظة العريش لرصد الوفرة الموسمية والنشاط النهاري والتأثير السلبي على طوائف النحل لمدة عامين متتاليين (٢٠١٩ و ٢٠٢٠). يتم أخذ العلاقات بين درجات حرارة الهواء المثلى والرطوبة النسبية والتقلبات الديناميكية للدبابير في الاعتبار.

أظهرت النتائج أن هناك زيادة في درجة الحرارة والرطوبة النسبية بنسبة ٤,٧ درجة مئوية و ٢,٩٪ بعد ثلاثة عشر عاما من أول تسجيل لهذه الدبابير في منطقة شمال سيناء. تم العثور على ارتباطات موجبة معنوية عالية بين ديناميكية اعداد الدبابير ودرجة الحرارة والرطوبة النسبية على التوالي. يبدأ عدد قليل من الأفراد من الدبابير في الظهور من مارس حتى مايو ، ثم لوحظ انخفاض عدد الدبابير في يونيو تليها زيادة تدريجية من الأسبوع الأول من يوليو حتى نهاية أكتوبر في سنتي الدرسة ، تم تسجيل أعلى أعداد من الدبابير خلال الأسبوعين الأول والرابع من شهر سبتمبر. يميل الدبور إلى الاختفاء من الأسبوعين الثاني أو الثالث من شهر نوفمبر. بالنسبة للنشاط النهاري للدبابير ، تم صيد أكبر أعداد خلال الفترات من ٩ صباحًا إلى ١٢ ظهرًا ومن ١٢ ظهرًا إلى ٣ مساءً في يوليو وأغسطس بينما سجلت الفترة قبل ٩ صباحًا وبعد ٣ مساءً أقل عدد من الدبابير. ومع ذلك ، خلال شهري سبتمبر وأكتوبر ، كانت أعلى الاعداد التي تم اصطيادها متناوبة في النصف الثاني من النهار ، (من ١٢ ظهرًا إلى ٦ مساءً). بدأت آثار زيادة اعداد الدبابير على طوائف نحل العسل في الظهور من الأسبوع الرابع من أغسطس في ٢٠١٩ ومن الأسبوع الثاني من سبتمبر في ٢٠٢٠. وكانت أعلى نسب القضاء على طوائف النحل في أكتوبر (٢٥,٣٪ في ٢٠١٩) ونوفمبر (١٩,١). ٪ في ٢٠٢٠). كانت النسبة الإجمالية للطوائف التي تم القضاء عليها ٥٧,٣٪ و ٤٤,١٪ خلال العامين على التوالي. وخلصت الدراسة إلى أن مستقبل التربية المستدامة للنحل في شمال سيناء في اماكن كثيرة مهددة بسبب زيادة تكاثر و انتشار الدبور الشرقى ويجب أن تبذل الكثير من الجهود لوضع برامج مكافحة متكاملة لهذا المفترس الخطير ويمكن ان يتضمن هذا البرنامج استخدام مصائد الخلية المعدلة لما لها من فعالية كبيرة من اصطياد اعداد كبيرة من افراد هذه الافة.

الكلمات المفتاحية: التغير المناخي ، الدبور الشرقى ، طوائف نحل العسل ، الوفرة الموسمية ، النشاط النهاري ،المكافحة، شمال سيناء.