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Spatial Distribution and Relative Abundance of Some Mosquito Species Transmitted Diseases in Beheira Governorate, Egypt

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ABSTRACT
Background: It is well known that mosquito species transmitted diseases such as: filariasis, malaria fever and allergy to humans.

Materials and Methods: Collected mosquito species adults were identified morphologically using recommended keys constructed by specialized authors. Also, different climatic factors (temperature, relative humidity, and wind velocity), of adult mosquitos' habitats were measured, and the relationship between climatic factors and adult mosquitos' abundance were investigated.

Results: The obtained results revealed that mosquito species in Beheira Governorate, Egypt, were represented by four genera and nine species these are: *Culex pipiens, Cx. antennatus, Cx. theileri, Cx. tritaeniorhynchus, Culiseta longiareolata, Aedes caspius, Ae. detritus, Anopheles multicolor* and *An. sergentii.* Based on statistical analyses, the abundance of adult mosquitoes had a moderately positive correlation at all species collected with temperature except *Ae. detritus* has a weak positive correlation. At the same time, relative humidity recorded a moderately negative correlation for all species studied except *Ae. detritus* which did not show correlation. In addition, wind velocity was negatively correlated at all species except *Ae. detritus* recorded weak positive correlation.

Conclusion: The most abundant mosquito species in the studied areas were *Culex pipiens* which have been collected throughout different seasons, which threatens the risk of spreading diseases transmitted by this species. Also, the abundance of mosquito species proved to depend on suitable climatic factors. So, more investigations are needed to select a proper control strategy.

Keywords: Mosquito, *Culex*, *Anopheles*, vector, borne diseases.

INTRODUCTION
Mosquitoes are a biological vector of many diseases such as filaria, malaria, dengue, and Rift Valley fever [1-5]. In Egypt, the most common mosquito-borne diseases include filaria [6], malaria [7] and dengue fever [8].

Also, mosquitoes negatively impact livestock by decreasing weight gain and milk production in dairy cows through disease transmission [9]. *Culicine* mosquitoes in Egypt, mainly *Culex pipiens* have a wide distribution, and it is the main vector of Rift Valley fever virus [10] and *Wuchereria bancrofti* [11].

Another *Culicine* mosquito in Egypt, *Culex antennatus*, is the main vector of the Rift Valley Fever virus during an outbreak in the Nile Delta of Egypt [12].

In addition, the role of *Anopheles* in malaria transmission in Egypt is well documented based on epidemiological evidence and the finding of naturally sporozoite-infected females [13]. On the other hand, climate changes and rising global temperatures affect distribution, density, and abundance of mosquito- borne diseases [14-16]. Good knowledge and understanding of mosquito species' biology and ecology are important and can help apply suitable vector control strategies [17-18].

AIM
Thus, the present study aimed at investigating the relative abundance and spatial distribution of different adult mosquito species in Beheira Governorate, Egypt, and the environmental factors affecting mosquitos' abundance.

MATERIALS AND METHODS
1. Survey of mosquito species:
1.1. Study sites:
The present study conducted in the locations listed in table (1) and illustrated in figure (1) namely, Shubrakhit, Abu Almatamir, Wadi Elnatrun and Idku, which belonging to Beheira Governorate, Egypt. A survey was carried out from January to December 2019.

Table 1: Different studied locations in Beheira Governorates, Egypt.

Location	Latitude (N)	Longitude (E)	Altitude
Shubrakhit	30° 59' 47.2	30° 42' 50.6	4
Abu Almatamir	30° 53' 53.6	30° 10' 03.2	-19
Wadi Elnatrun	30° 22' 39.9	30° 20' 50.2	-11
Idku	31° 17' 54.3	30° 18' 46.8	-3

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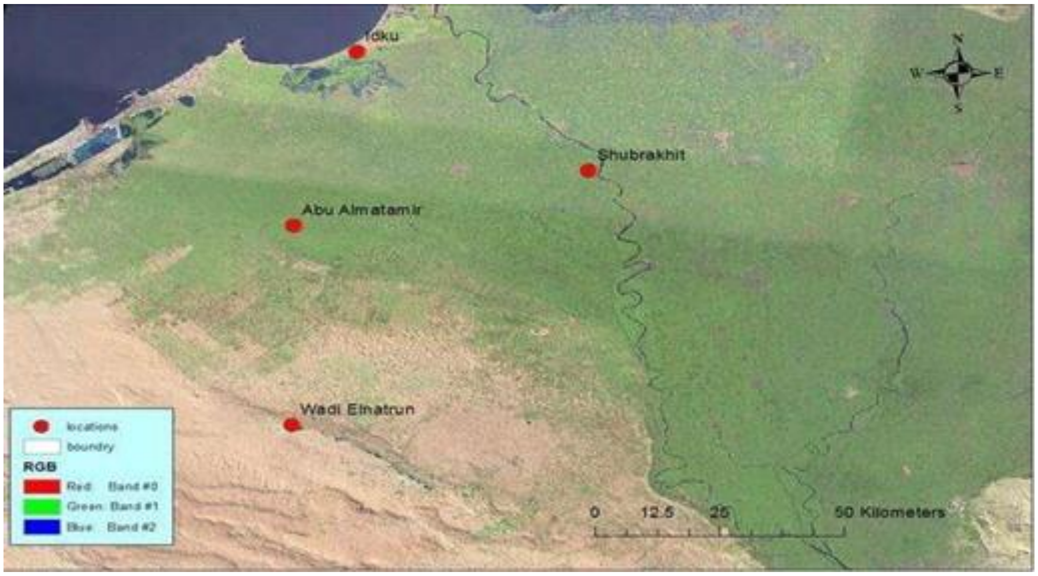

Figure (1): Locations of Beheira Governorate' study areas; Shubrakhit, Abu Almatamir, Wadi Elnatrun and Idku.

1.2. Adult collection:

Three randomly houses in each study area were selected for collection of adult mosquitoes between 06:00-10:00 pm hrs. by CDC- light trap (Manufactured by John W. Hock Company, USA) recommended by WHO**.**

Traps were placed at homes' entrances at a height of one meter. The collected mosquitoes were stored in screened labeled paper cups with cotton wetted with glucose solution 10% [19] and identified morphologically using previous described keys [20- 22].

On the other hand, indoor and outdoor; temperature and relative humidity were calculated using LCD digital temperature and humidity meter (HTC-1). while wind velocity outside the houses was calculated using digital anemometer (WT816A).

2. Statistical analysis

All statistical analyses were carried out using Statistical Package Social Science (SPSS) software version 26 powered by IBM SPSS Statistics. Data visualization becomes available using R-studio V.4.1.3.

Ethical Approve:

The study has been approved from the ethical committee from Faculty of Science, Al-Azhar University.

RESULTS

Mosquito species in Beheira Governorates, Egypt were represented by nine species belong to four genera: *Culex pipiens, Cx. antennatus, Cx. theileri, Cx. tritaeniorhynchus*, *Culiseta longiareolata*, *Aedes caspius*, *Ae. detritus*, *Anopheles multicolor* and *An. sergentii*.

1. Relative abundance and spatial distribution of mosquitoes' adult:

The relative abundance of adult mosquito species collected from the Shubrakhit region, Beheira Governorate, Egypt, was recorded in figure (2, 3). As shown from the data, *Cx. pipiens* represented the most common mosquito specie, with 39.77% of total mosquito species, whereas only 401 *Cx. tritaeniorhynchus* adults (3.69% of total mosquitoes) were collected throughout the entire period of the study. Also, the highest number (2310) represented 21.28% of the total mosquito adults collected recorded in Aug. Meanwhile, 71 mosquito adults (0.65% of total mosquitoes) were collected in Jan.

Regarding Abu Almatamir region, the lowest numbers of adult mosquitoes collected throughout the study (315 and 387) were recorded for *An. multicolor* and *An. sergentii* represented 3.38 and 4.16% of the total mosquitoes' adults collected. The highest abundance of adult mosquito species obtained was from Abu Almatamir region recorded in Aug. (22.57%), while the lowest abundance of adult mosquito species was recorded in Jan. (0.62%) (figure 4, 5).

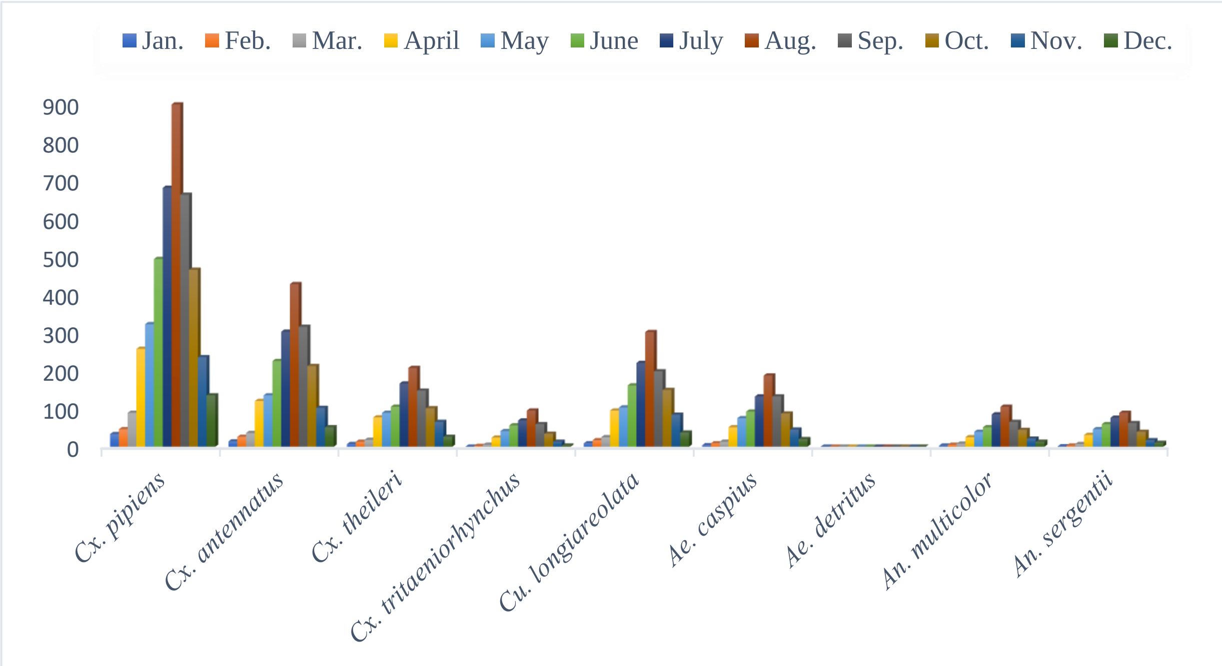

Fig. (2): Gradient chart showing relative abundance of adult mosquito species collected from Shubrakhit region, Beheira Governorate, Egypt, from January to December 2019. *Cx.: Culex*, *Cu.: Culiseta*, *An: Anopheles*, *Ae: Aedes*

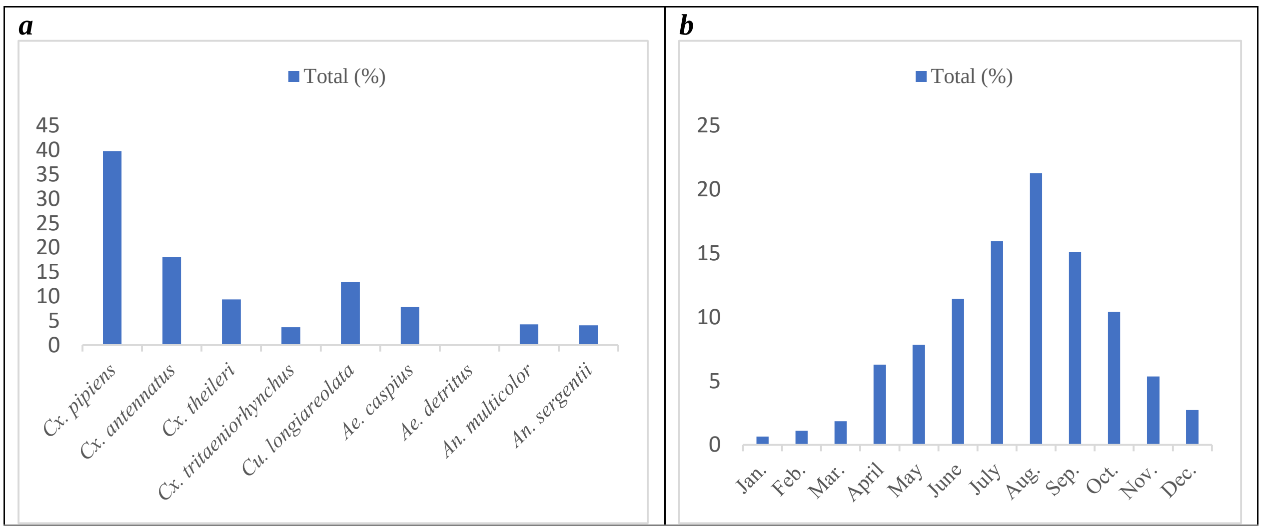

Fig. (3): (a, b) Gradient chart showing relative abundance of total adult mosquito species collected from Shubrakhit region, Beheira Governorate, Egypt, from January to December 2019. See capture of figure (2).

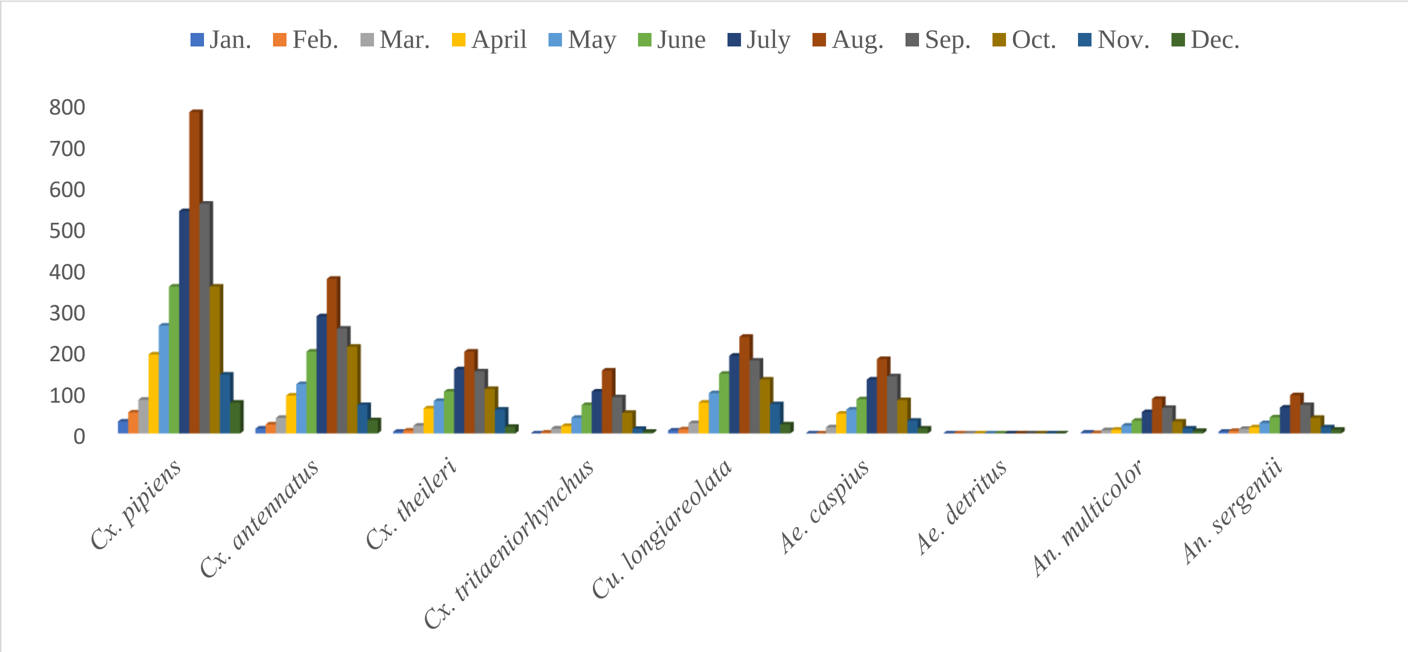

Fig. (4): Gradient chart showing relative abundance of adult mosquito species collected from Abu Almatamir region, Beheira Governorate, Egypt, from January to December 2019. See capture of figure (2).

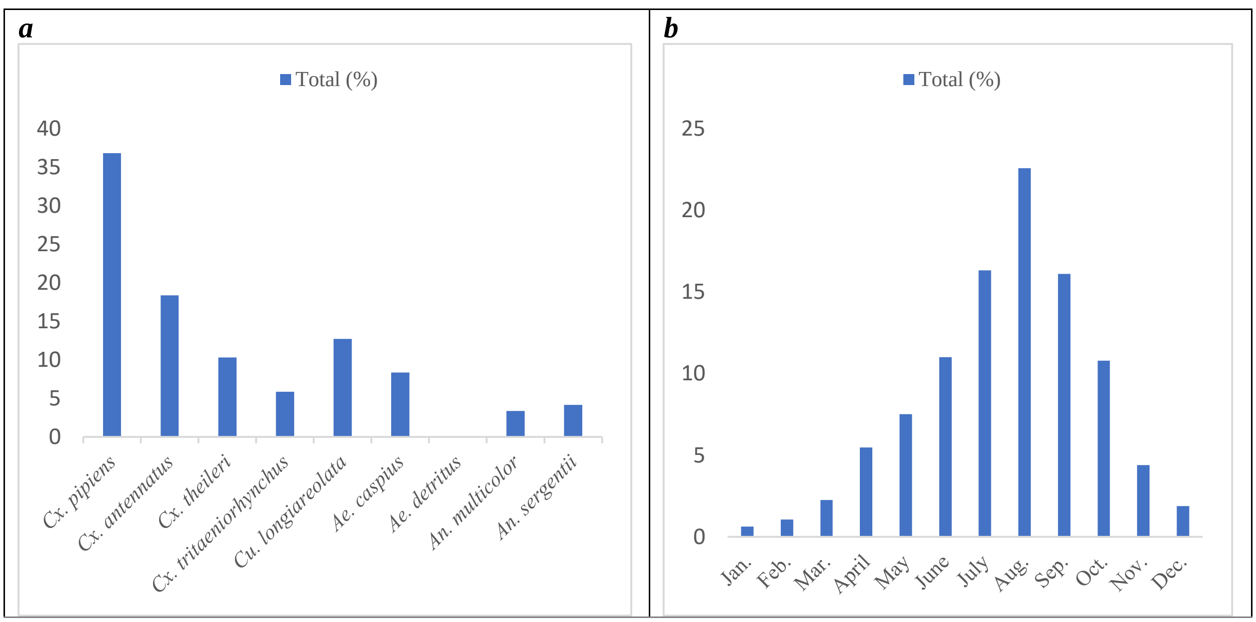

Fig. (5): (a, b) Gradient chart showing relative abundance of total adult mosquito species collected from Abu Almatamir region, Beheira Governorate, Egypt, from January to December 2019. See capture of figure (2).

Data in figure (6, 7) recorded the population diversity of adult mosquito species collected from the Wadi Elnatrun region throughout the period from Jan. to Dec. The obtained data showed that the highest numbers of adult mosquitoes collected throughout the study (3350 and 1628) were recorded for *Cx. pipiens* and *Cx. antennatus* represented 37.19 and 18.07% of the total mosquitos' adults collected. The highest abundance of adult mosquito species obtained was recorded in Aug. (23.23%), followed by July (16.54%) and Sep. (15.60%). On the other hand, the highest relative abundance of mosquito adults collected from the Idku region (31.65%) was recorded for *Cx. pipiens* followed by *Cx. antennatus* (21.01%) and *Ae. detritus* (12.37%). Also, the highest number of mosquito adults (2017) represented 23.32% of mosquito adults collected recorded in Aug. Whereas, whereas only 40 mosquito adults (0.46% of the total mosquitoes) were collected in Jan. (figure 8, 9).

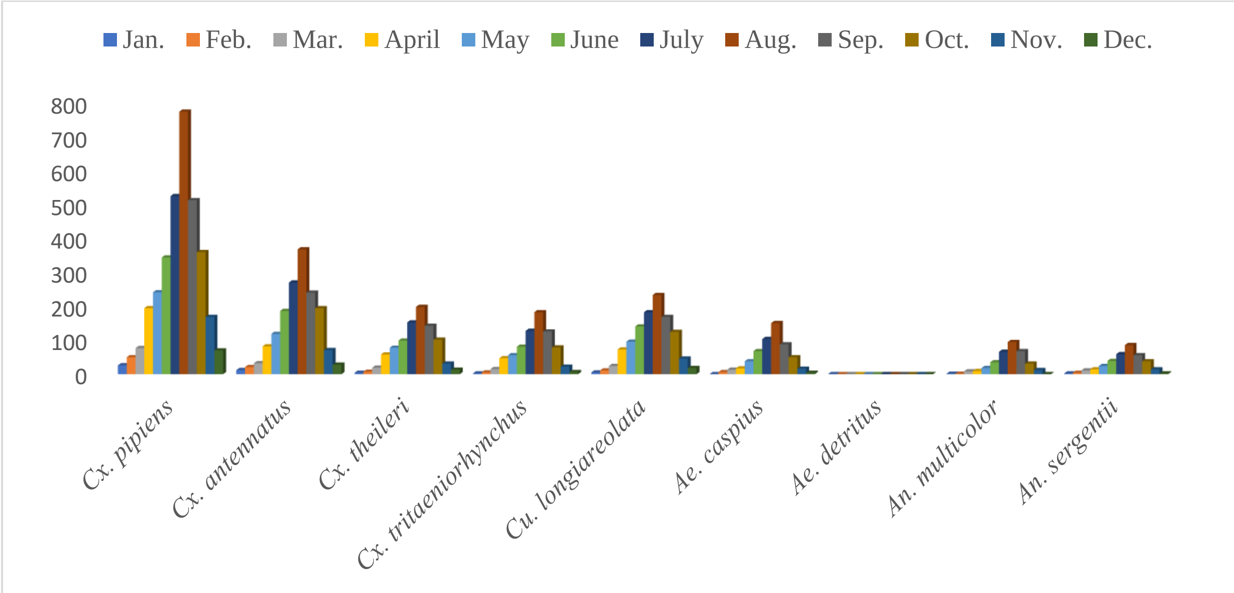

Fig. (6): Gradient chart showing relative abundance of adult mosquito species collected from Wadi Elnatrun region, Beheira Governorate, Egypt, from January to December 2019. See capture of figure (2).

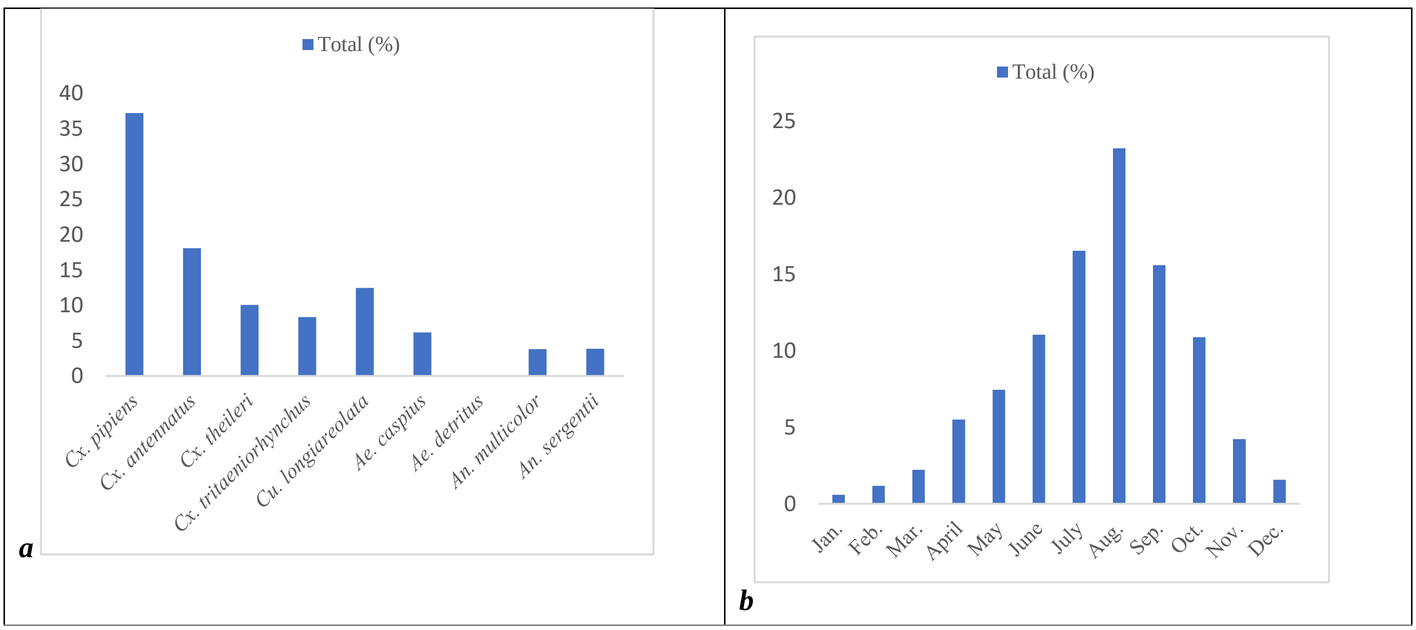

Fig. (7): (a, b) Gradient chart showing relative abundance of total adult mosquito species collected from Wadi Elnatrun region, Beheira Governorate, Egypt, from January to December 2019. See capture of figure (2).

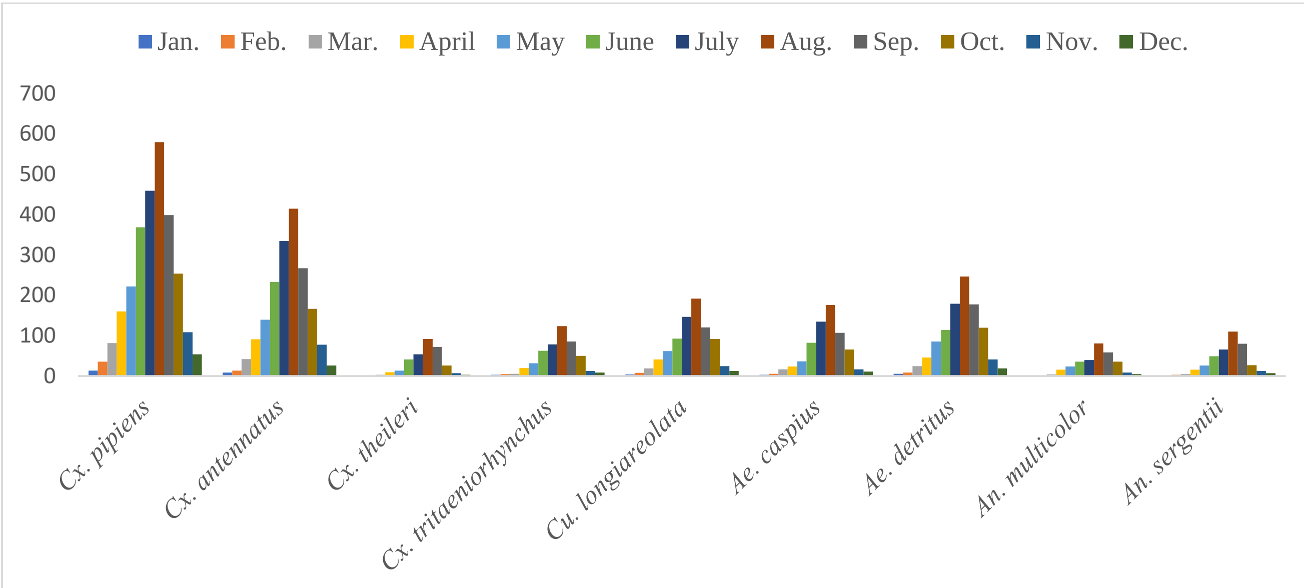

Fig. (8): Gradient chart showing relative abundance of adult mosquito species collected from Idku region, Beheira Governorate, Egypt, from January to December 2019. See capture of figure (2).

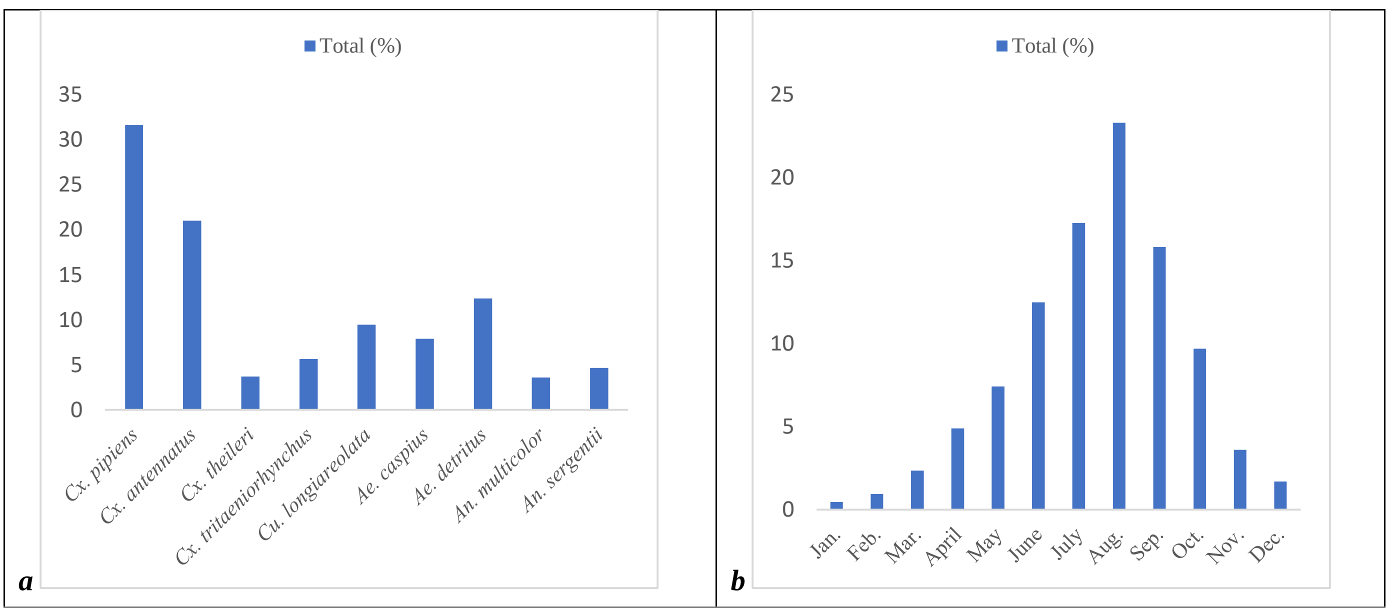

Fig. (9): (a, b) Gradient chart showing relative abundance of total adult mosquito species collected from Idku region, Beheira Governorate, Egypt, from January to December 2019. See capture of figure (2).

2. Climatic factors of adult mosquito habitats:

Throughout the study period, the figure (10) recorded climatic factors of adult mosquito habitats in the Shubrakhit region, Beheira Governorate, Egypt. The lowest indoor temperature was 12.9˚C in Jan and Dec., while the highest outdoor temperature was 37.1°C in May. The highest outdoor RH (%) was recorded at 84.2 in March, compared with 82.3% for indoor RH in the same month. Also, the highest wind velocity was recorded at 24.1 km/h in Feb. Also, the highest indoor temperature in Abu Almatamir region (35.4˚C) was recorded in May and the outdoor temperature (38.2˚C) in the same month. The outdoor temperature was recorded at 39.4, 37.4 and 33.7 during the summer (June, July and Aug.), respectively. The highest outdoor RH was recorded, 87.1%, in March. In addition, the lowest wind velocity (10.2 km/h) was recorded in July (Figure 11).

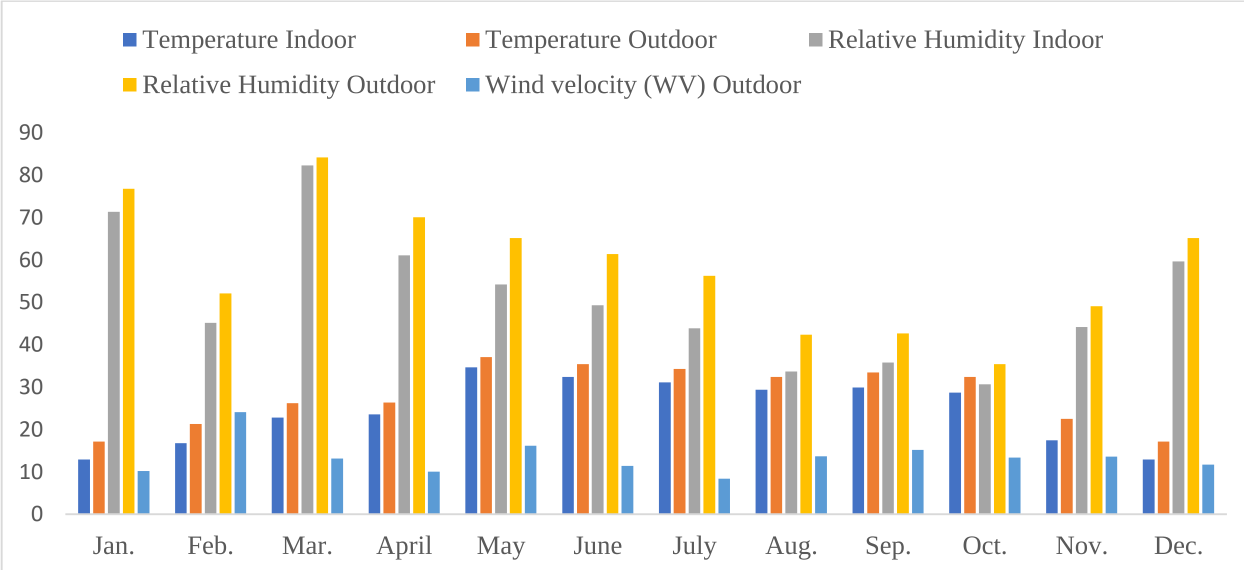

Fig. (10): Gradient chart showing climatic factors at the adult mosquito habitats in Shubrakhit region, Beheira Governorate, Egypt, throughout the study period from January to December 2019. Temp.: Temperature, RH.: Relative Humidity, WV.; Wind Velocity.

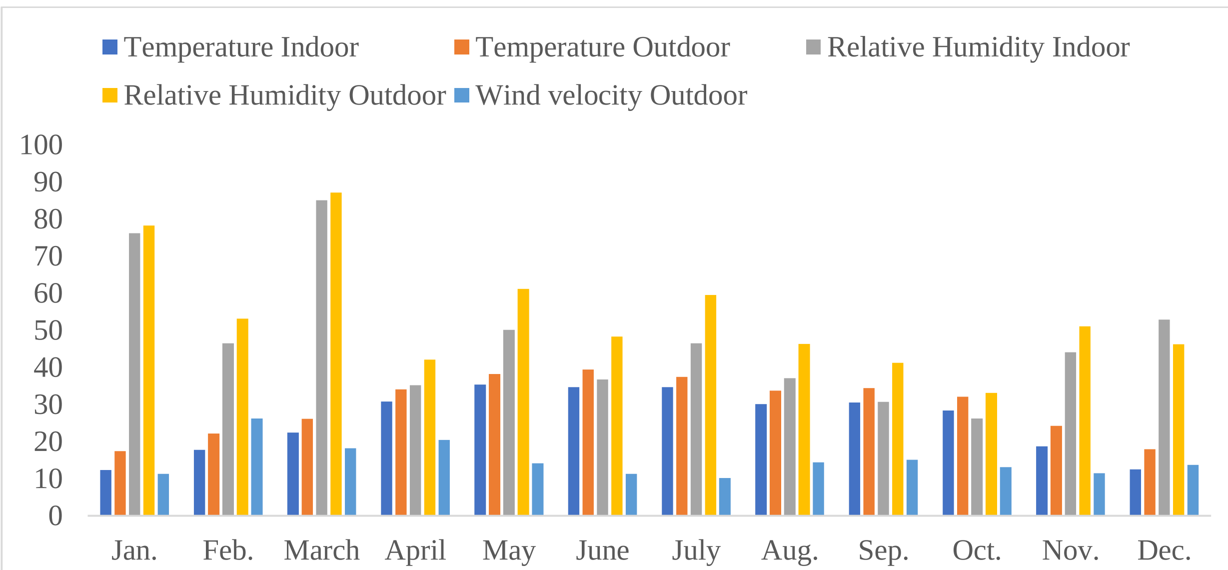

Fig. (11): Gradient chart showing climatic factors at the adult mosquito habitats in Abu Almatamir region, Beheira Governorate, Egypt, throughout the study period from January to December 2019. See capture of figure (10).

In addition, the highest indoor temperature in Wadi Elnatrun region (36.9˚C) was recorded in May, while the highest outdoor temperature (39.1˚C) was recorded in the same month. The outdoor temperature was recorded at 38.1, 37.2 and 32.5˚C during the summer season (June, July and Aug.), respectively. The lowest outdoor RH was recorded at 31.2% in Oct. In addition, the highest wind velocity (33.2 km/h) was recorded in March. (Figure 12). Regarding the Idku region, the lowest indoor temperature (13.1˚C) was recorded in Jan. and the outdoor temperature (15.3˚C) in the same month. The lowest indoor RH was recorded at 40.1% in June, compared with 52.4% for outdoor RH in the same month. Also, the lowest wind velocity recorded 13.2 km/h in July and November (Figure 13).

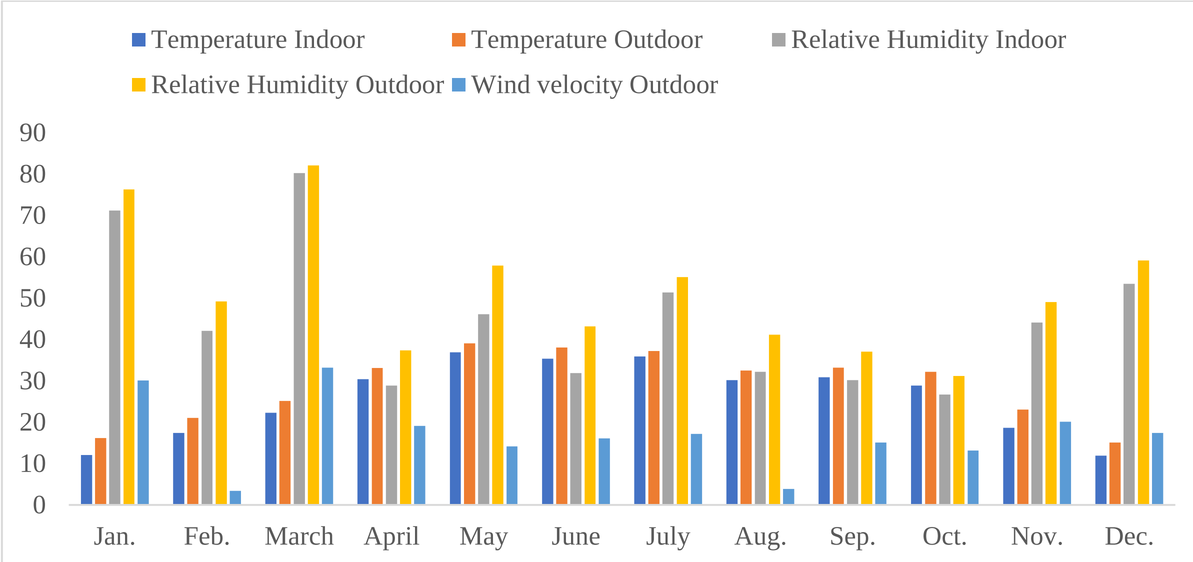

Fig. (12): Gradient chart showing climatic factors at the adult mosquito habitats in Wadi Elnatrun region, Beheira Governorate, Egypt, throughout the study period from January to December 2019. See capture of figure (10).

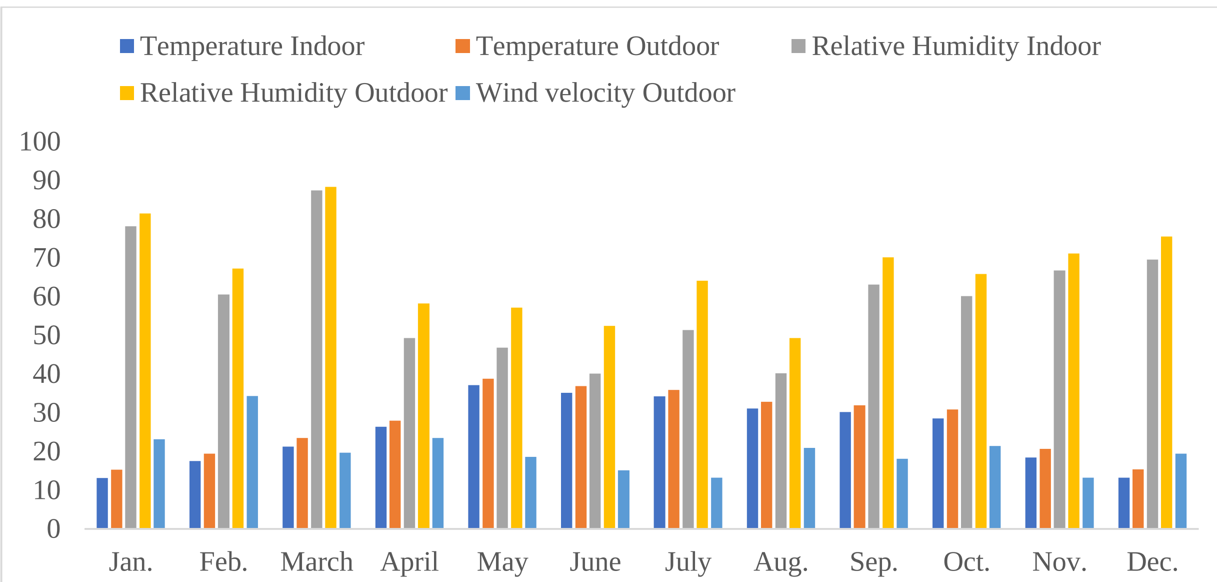

Fig. (13): Gradient chart showing climatic factors at the adult mosquito habitats in Idku region, Beheira Governorate, Egypt, throughout the study period from January to December 2019. See capture of figure (10).

3. Relationship between climatic factors and abundance of adult mosquito:

Table (2) showed the correlation between different climatic factors of adult mosquito species in Beheira Governorate and the abundance of adult mosquitoes throughout the study period from Jan. to Dec. 2019. The abundance of adult mosquitoes was moderately had positive correlation (highly significant) at all species with temperature except *Ae. detritus* recorded a weak positive correlation (non-significant). The correlation values ranged between 0.212 and 0.727 at *Ae. detritus* and *Cu. Longiareolata*. The correlation between species abundance and relative humidity have moderately negative (highly significant) for all species except *Ae. detritus* showed no correlation (non-significant). The correlation values ranged between -0.592 at *Cx. theileri* and 0.097 at *Ae. detritus.* On the other hand, the correlation between species abundance and wind velocity recorded moderately negative for all species except *Ae. detritus* was a weak positive correlation (non-significant). The correlation values were ranged between -0.445 at *Cx. theileri* and 0.128 at *Ae. detritus.* (Table 2).

Table 2: The Correlation between different climatic factors and the adult mosquito species in Beheira Governorate, throughout the study period from January to December 2019.

Climatic Factors	Mosquito Species Collected								
	Cx. pipiens	*Cx. antennatus*	*Cx. theileri*	*Cx. tritaeniorhynchus*	*Cu. longiareolata*	*Ae. caspius*	*Ae. detritus*	*An. multicolor*	*An. sergentii*
Temperature (˚C)	0.691**	0.709**	0.669**	0.681**	0.727**	0.680**	0.212	0.627**	0.674**
Relative Humidity (RH)	-0.556**	-0.514**	-0.592**	-0.478**	-0.574**	-0.470**	0.097	-0.466**	-0.434**
Wind velocity (WV)	-0.402**	-0.354*	-0.445**	-0.319*	-0.413**	-0.350*	0.128	-0.353*	-0.328*

*: significant (P<0.05); **: highly significant (P<0.01). See the footnote of figure (2).

DISCUSSION

Beheira Governorate located in the western part of the Delta area, Egypt. The Mediterranean Sea bordered it on the north, the Rosetta branch on the east, Alexandria and Matrouh on the west, and Giza and El-Menofia on the south. The city of Damanhur serves as the country's capital. Many of the Delta region's water bodies are found in this Governorate. Beheira Governorate with a population density of around 500 people per square kilometer. Most of the land is used for agriculture. Agriculture, especially rice crop, was known to be a suitable habitat for mosquito breeding abundance. The food industry is the Governorate's main economic resource. Wheat, rice, and cotton are the most important crops, along with certain fruits and flowers. Water bodies and some animals like cows, horses, birds, and foxes are found in the governorate impacting the mosquitoes' occurrence and abundance. The Governorate's favorable temperature and relative humidity also aid in transmitting diseases by mosquitoes. The *Cx. pipiens* was the most prevalent species in all locations studied. *Culicine* mosquitoes worldwide and in Egypt are the main vectors of the West Nile virus [(23)], filariasis [(24)], Rift Valley fever (RVF) virus [(2)] and several other viruses [(25)].

In the present study, mosquitoes adults collected from Beheira Governorate were represented by nine species belonging to four genera: *Culex pipiens* 36.57% (13830/37820), *Cx. antennatus* 18.83% (7121/37820), *Cx. theileri* 8.48% (3209/37820), *Cx. tritaeniorhynchus* 5.78% (2188/37820), *Cu. Longiareolata* 11.97% (4526/37820), *Ae. caspius* 7.57% (2863/37820), *Ae. detritus* 2.83% (1070/37820), *An. multicolor* 3.79% (1434/37820) and *An. sergentii* 4.18% (1579/37820). All species are related to the Egyptian fauna there is not any invasive species. Similarly, several previous studies recorded the same species in different Governorates in Egypt [(6, 26- 29)].

The potential factors of mosquito vectors in Beheira Governorate are rice agriculture, human population density, animals, rainfall, drains, sewage, and seepage and domestic drainage canals, which are observed to be close to residential areas; this indicates that a lack of sanitation of the most locations in the study area appears to be responsible for the abundance of mosquito habitats this agrees the previous study recorded that the densities of vectors increased with rainfall, rice agriculture ratio and human population density variables in Hanoi, Vietnam [(30)]. Also, the presence of *Cx. pipiens* is epidemiologically important since it is the main vector of the RVF virus, bancroftian filariasis and West Nile virus [(11, 31)].

In the present study, the temperature registered in the four-breeding region in Beheira Governorate was seemed to affect the number of mosquitoes collected, whereas, in the Shubrakhit region, about 2310 mosquito adults (21.28%) were collected in Aug. 2019. While at Abu Almatamir region abundance of mosquito adults recorded the highest levels in months (July, Aug., and September) with 16.31, 22.57 and 16.10 % of total collected mosquito adults, as compared with the months with 1.89, 0.62 and 1.06% of total collected mosquito adult, respectively. Where at Wadi Elnatrun region, about 2092 mosquito adults (23.23%) were collected in Aug. 2019. Also, at Idku region recorded the highest abundance of mosquito adults in Aug. 2019. About 2017 mosquito adult. The indoor temperature range was recorded between 11.9 to 37.1˚C. These results agreed previous results reported that a temperature of more than 40°C is unsuitable for rapid mosquito growth [(32)] and contradicted those recorded that a temperature range of 17-30˚C for *Cx. pipiens*, and *Cu. Longiareolata* in Cairo Governorate and a temperature range of 21-32°C for *Cx. pipiens*, and *Cu. Longiareolata* in different breeding sites in Egypt [27, 33]. The indoor relative humidity (RH) range was recorded between 26.2 to 87.4 %. It is suitable for the high abundance and spread of adult mosquitoes. These results contradicted the relative humidity (RH) of 4-69 % for 3 genera *Culex*, *Aedes* and *Anopheles* [34] in Eastern Province, Saudi Arabia.

CONCLUSION

From the present study, we can conclude that mosquito species in Beheira Governorate, Egypt, were represented by nine species belonging to four genera. The most abundant mosquito species in the study area were *Culex pipiens* which collected throughout different seasons, which threatens the risk of spreading diseases transmitted by this species. Also, the abundance of mosquito species proved to depend on suitable climatic factors. So, more investigations are needed to select a proper control strategy.

Conflict of Interests: The authors of this paper declare that they have no financial or personal relationships with individuals or organizations that would unacceptably bias the content of this paper and therefore declare that there is no conflict of interests.

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