Libyan Journal of Ecological & Environmental Sciences and Technology
(LJEEST)

LJEEST
ISSN: 2710-5237
www.srcest.org.ly/jou

http://aif-doi.org/LJEEST/060103

Using Climate Scenarios to Influence Temperature on *Aedes Albopictus* Mosquito Over the City of Al Bayda, Libya

Nawal .A. Mahfoud [1], Haifa M. Ben Miloud [2]

ARTICLE INFO

Vol. 3 No. 1 June, 2024
Pages (12- 17)

Article history:
Revised form 28 December 2023
Accepted 30 January 2024

Authors affiliation
[1]Department of Zoology, Faculty of Science, University of Tripoli, Libya.
[2]Department of Atmospheric Scienc, Faculty of Science, University of Tripoli, Libya.

nawalmahfud9@gmail.com[1]
regcm00@Yahoo.com[2]

Keywords: Climate change, mosquito *Aedes albopictus*, temperature, Libya, RCP(Representative Concentration Pathway).

ABSTRACT

The world highlights climate changes using several scenarios that are used in this study. The RCP45 and RCP85 scenarios were used to examine the annual effect of temperature on the quantities of disease-carrying *Aedes albopictus* mosquitoes from the period 1986-2085, as they were found in humid and low-temperature places, and since the city of Al Bayda has a dense vegetation cover, it became clear that the *Aedes albopictus* mosquitoes reproduce in the environment. On the other hand, it is concentrated in the north more than in the south of the city due to the cooling of temperatures in the north of the city overlooking the sea. Through statistical analysis, it was found that there is a strong negative correlation between temperature and *Aedes albopictus* mosquitoes, reaching -0.819, -0.814 for the RCP45 and RCP85 scenarios Respectively.

استخدام سيناريوهات المناخ لتأثير درجة الحرارة على البعوضة المنقطة البيضاء فوق مدينة البيضاء ليبيا

نوال عبد السلام محفوظ[1] , هيفاء محمد جمعة بن ميلود[2]

العالم يسلط الضوء على التغيرات المناخية باستخدام العديد من السيناريوهات والتي استخدمت في هذه الورقة. تم استخدام سيناريو **RCP45,RCP85** لتأثير السنوي لدرجة الحرارة على كميات *البعوضة الزاعجة المنقطة البيضاء* الناقلة للأمراض من الفترة **1986–2085** , وحيث تواجدها في الاماكن الرطبة و المنخفضة الحرارة , وحيث ان مدينة البيضاء لديها غطاء نباتي كثيف اتضح بان *البعوض الزاعجة المنقطة البيضاء* يتكاثر في البيئة الملائمة لها, ومن الناحية الاخرى يتمركز في الشمال اكثر من جنوب المدينة بسبب تلطيف لدرجات الحرارة في الشمال المدينة المطلة على البحر, ومن خلال التحليل الاحصائي تبين هناك ارتباط قوي سلبي بين درجة الحرارة *والبعوضة الزاعجة المنقطة البيضاء* يصل الى **–0.819, –0.814** للسيناريو **RCP45, RCP85** على التوالي.

INTRODUCTION

LIBYA climate ranges from a temperate Mediterranean climate in isolated areas on the Mediterranean coast to a tropical desert climate in the vast majority of the country's interior. The northern Mediterranean areas of Libya have dry summers and mild winters, with the majority of the precipitation falling in the winter. The highlands near Tripoli and Benghazi experience cooler temperatures and receive the most rain of any region in Libya (USAID ,2017). From Libya cites which are located in the north of the country Al Bayda city and

are located 600 meters (2,000 feet) above sea level on the the green Mountain Hills, which receive 540 mm (21 inches) of rain annually. In the winter, due to the altitude, snow can fall during cold waves, and the average daily temperature ranges from 10 °C (50 °F) in January and February to 23.5 °C (74 °F) in August (www.Climatestotravel .com), and despite Libya vulnerability to the impacts of climate change, there has been little progress towards the development and implementation of national disaster risk reduction or climate change adaptation strategies or plans. Continued environmental degradation threatens further deterioration of terrestrial and marine environments and ecosystems without meaningful action (www.undp.org/libya). The world has experienced perceptible climate change for the past 100 years. Global warming enhances the rapid spread of mosquito-borne diseases resulting in unknown consequences in the future, and it has global economic development, increased urbanization, and climate change have significantly increased the mosquito-borne disease transmission pattern and dynamics (Anoopkumar. A& M. Embalil, 2022). Global warming has shortened mosquitoes' lifecycle period and increased the disease transmission rates by mosquito vectors where mosquito-borne diseases: malaria, dengue fever, and the Japanese encephalitis Billions of people get infected with those diseases and millions of people die every year (Hoonbok Yi, *et al.*,2015). Due to local, daily, and seasonal thermal variations, insects have to face risks including desiccation, changes in metabolism, and even losing the ability to move. However, through evolutionary times, insects have developed various strategies to cope with these thermal variations and avoid thermal stress (Joanna, *et al.*,2018& Pengfei Jia, *et al.*,2017), and Anthropogenic alterations in the environment deeply affect the overall biodiversity of species in a non-random process, resulting in species loss and subsequent increase in abundance of a few species that are able to thrive in urban environments (Giovanni, *et al.*,2021).

The *Aedes albopictus* (Skuse) or Asian tiger mosquito, was originally described 120 years ago based on specimens collected in Calcutta, India(Roberta. *et al.*,2014) ,and *Aedes albopictus* is the main vector of dengue and a number of other diseases worldwide. Because of the domestic nature of this mosquito, the relative importance of macroclimate in shaping its distribution has been a controversial issue (César, *et al.*, 2014).This species originated in Asia, with a few decades, this species expanded its distribution area to North and South America , Africa and Europe , but only spread over the Mediterranean after additional introductions to Italy a decade later. It is now established in at least 19 European countries(Lisa, *et al.*, 2019), but it has spread worldwide over the past few decades via human travel and international commerce(Lisa, *et al.*, 2019& Pedro, *et al.*, 2014), and in this context, mosquito vectors such as *Aedes albopictus* benefit from urbanization processes, and consequently have increased their presence and range (Antonios, *et al.*, 2021).

STUDY AREA

The study area is the city of Al-Bayda, located of northern east Libya between latitudes 32.94 - 31.12 N^0 and longitudes 21.25 - 21.93 E^0, it is distinguished by its beautiful vegetation cover.

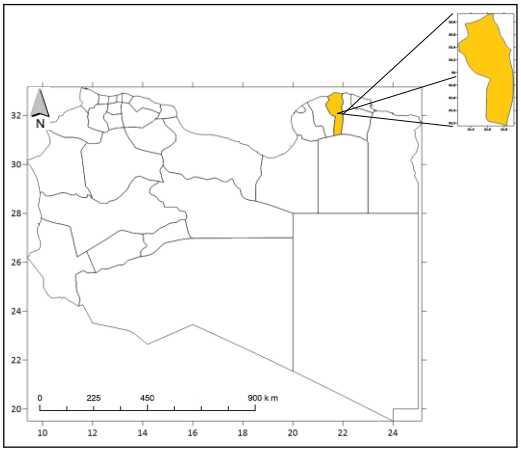

Fig. (1): Study Area .

DATA SOURCE

The study used (Daily counts) for *Aedes albopictus* mosquito And take its annual average, and data temperature (C^0) using climate scenarios RCP 45, RCP 85 (Representative Concentration Pathway) has been defined RCP 4.5 is described by the IPCC as an intermediate scenario between RCP26 a low carbon emission future and RCP85 in a high carbon future (IPCC, 2014), for period 1986-2085. The data were downloaded from Climate Data Store - Copernicus (www.cds.climate.copernicus.eu).

SPACE AND TIME DISTRIBUATION

The city of AL Bayda is considered one of the beautiful Libyan cities with its picturesque view of vegetation, and it is considered the focus of attention for the biological diversity of plants and insects, as well as climate factors that play a major role in this diversity.

Figure 2 shows that the average annual number of mosquitoes is more concentrated in the north than in the south of the city, where the number reaches 60-125, compared to a decrease in temperature and reaches 16.4-16.8, while in the south it reaches 10-35, where the temperature rises. 20.4-20.8 during the period 1986-2023 for the RCP45 climate scenario see Figure (2.a,c), while in the period 2024-2085 we notice an increase in

temperatures in the north by about 17.4-17.8, and the amount of mosquito populations decreases by about 60-120, while in the south the temperature rises clearly, reaching 21.8-22, and the numbers of mosquitoes decrease, see Figure (2.b, d), and in the first period, where temperatures are lower than the second period, therefore mosquitoes increase in the first period than the second, and an influence factor temperature is more apparent when using the RCP85 climate scenario. Notice a higher temperature increase than the RCP45 scenario, and thus the spatial distribution of mosquito quantities in the north and south of the city decreases. See Figure (3.a, b). During the period 1986-2023 and 2024-2058, the quantities of mosquitoes decrease due to the climate factor is temperature, where the RCP85 scenario has higher temperatures than the RCP45 scenario, as shown in the time series for both mosquitoes and temperature. The time series shows that as temperatures increase, the number of mosquitoes decreases until 2085, depending on the use of climate scenarios see Figure4.

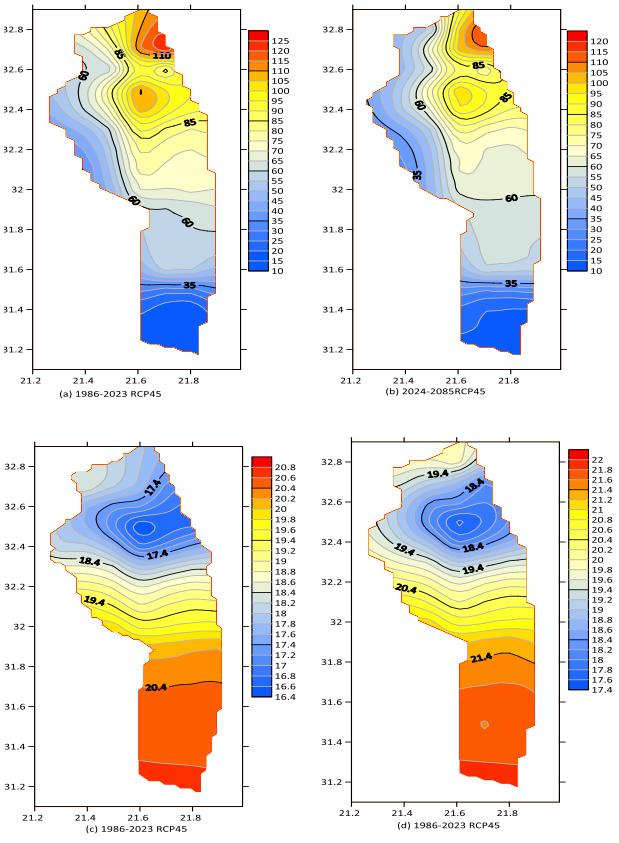

Fig .(2): (a, b) Average annual distribution of the number of *Aedes albopictus* mosquito &(c, d) Average annual temperature for the periods 1986-2023 and 2024-2085 for the RCP45 scenario.

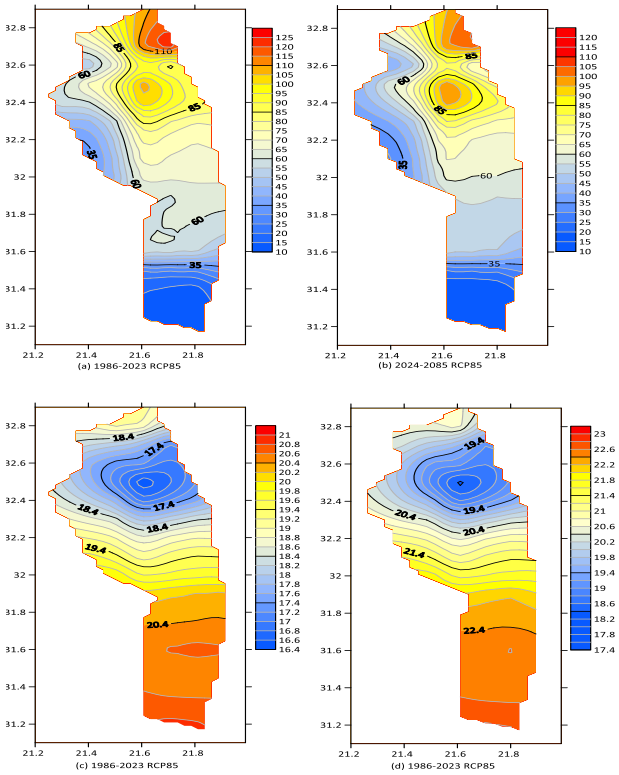

Fig .(3): (a, b) Average annual distribution of the number of *Aedes albopictus* mosquito &(c, d) Average annual temperature for the periods 1986-2023 and 2024-2085 for the RCP85 scenario.

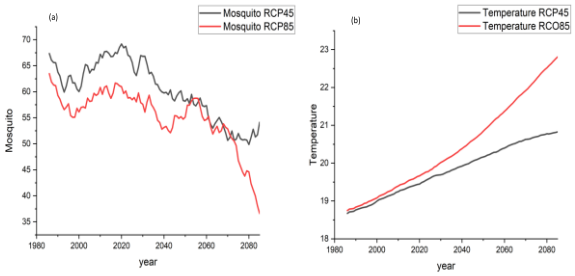

Fig .(4): (a) Time series of average annual of the number of *Aedes albopictus* mosquito, (b) average annual temperature (C^0) for the period 1986-2085 for the RCP45, RCP85 scenarios.

RESULTS AND DISCUSSION

For clarification, statistical techniques were applied in the current study. To ascertain the kind and degree of correlation between each temperature variable (C^0) and the number *of Aedes albopictus* mosquitoes in Al Bayda city for the RCP45 and RCP85 climate scenarios. Strong inverse correlation exists between temperature and *Aedes albopictus* mosquito, with values of (-0.819) and (-0.814) for the climate scenarios RCP45 and RCP85,

respectively, according to Table 1 Pearson correlation coefficient analysis.

Table (1): Statistics

	Season length Mosquito RCP45	Season length Mosquito RCP85
Number of Points	100	100
Degrees of Freedom	98	98
Residual Sum of Squares	1029.4034	980.18003
Pearson's r	-0.81999	-0.81481
R-Square (COD)	0.67239	0.66392
Adj. R-Square	0.66904	0.66049

According to the above table, the percentage effect of temperature, the independent variable, on the dependent variable, *Aedes albopictus* mosquito, is equal to 0.669, 0.660 for the RCP45, and RCP85 climate scenarios, respectively. This means that, for the RCP45 and RCP85, respectively, temperature affects *Aedes albopictus* mosquito by (66.9%, 66.0%). Additionally, as shown in table 2, the correlation coefficient R's square is used to determine the percentage change in the dependent variable as well as the degree to which it can be predicted independently.

Table (2):Summary

	Intercept		Slope		Statistics
	Value	Standard Error	Value	Standard Error	Adj. R-Square
Mosquito RCP45	199.076	9.79049	-7.00355	0.49383	0.66904
Mosquito RCP85	130.819	5.44008	-3.6994	0.26588	0.66049

Following that, the impact of temperature on *Aedes albopictus* mosquitoes was investigated by taking into account temperature as an independent variable and *Aedes albopictus* mosquitoes as a dependent variable. Data from the two variables were then analyzed using a straightforward method for the years 1986 to 2085. equation for linear regression.

$$y=a + b\,x$$

In order to determine the significance of the model's quality, we used analysis of variance. Because we observed a linear relationship and a level of significance for F that is less than 0.05, which indicates that the independent and dependent variables are related and that the regression model is significant, therefore we reject the null hypothesis and accept the alternative hypothesis that the model An important statistic and whose results can be relied upon, see Table 3,4.

Table (3):Parameters

		Value	Standard Error	t-Value	Prob>|t|
Mosquito RCP45	Intercept	199.076	9.79049	20.3335	6.151E-37
	Slope	-7.00355	0.49383	-14.18	1.75E-25
Mosquito RCP85	Intercept	130.819	5.44008	24.0472	6.801E-43
	Slope	-3.6994	0.26588	-13.914	6.135E-25

From the ANOVA table.4 to test the significance of the regression we note that the value of F is equal to 201.13-193.59 respectively, with a probability of 0.0001 less than 0.05, which indicates the quality of the regression model and that it is statistically significant, and therefore the existence of a relationship between the two variables show figure 5.

Table (4):ANOVA

		DF	Sum of Squares	Mean Square	F Value	Prob>F
Mosquito RCP45	Model	1	2112.74	2112.74	201.13	1.75E-25
	Error	98	1029.40	10.50		
	Total	99	3142.12			
Mosquito RCP85	Model	1	1936.31	1936.31	193.59	6.135E-25
	Error	98	980.18	10.00		
	Total	99	2916.49			

Mosquito RCP45: At the 0.05 level, the slope is significantly different from zero.
Mosquito RCP85: At the 0.05 level, the slope is significantly different from zero.

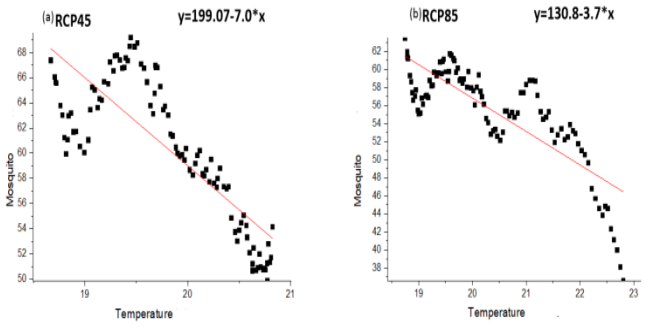

Fig. (5): Scatterplot of number of *Aedes albopictus* mosquito and temperature (C^0)

The points approach the line the of the regression equation and that the residuals are distributed according to the normal distribution, which is a condition for applying the regression equation ,as shown in the figure .6.

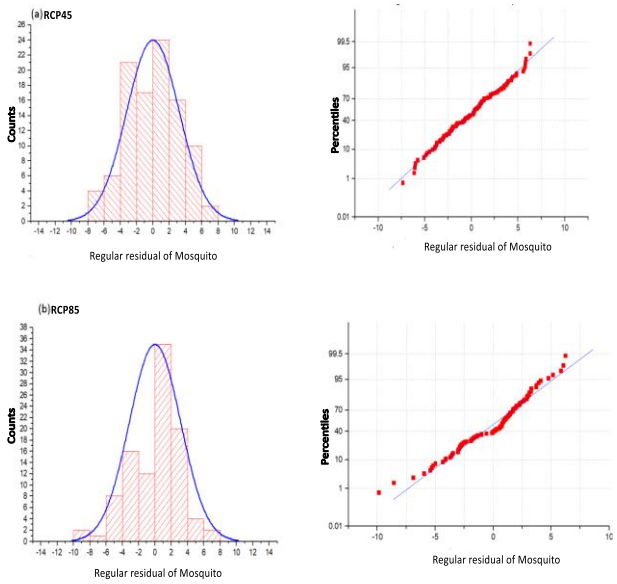

Fig.(6): Normal plot of regression residual

CONCLUSION

Climate changes affect humans, animals, plants, and the biological diversity of the environment on the surface of the Earth in general. Here, the effect of temperature on the spread of *Aedes albopictus* mosquitoes in the city of Al Bayda, which is characterized by a Mediterranean climate in the north and a desert climate in the south, was highlighted here. It is considered to have a dense vegetation cover and is concentrated in the Green Mountain. Therefore, through climate scenarios RCP45 and RCP85 for the time period 1986- 2085. It is clear that this *Aedes albopictus* has arrived in northern Libya, especially in large quantities in the north-east of Libya, as its movement across the Mediterranean Sea previously demonstrated (Lisa , *et al.*, 2019).

The number of *Aedes albopictus* mosquitoes increased in the north of the city by about 125 at a temperature of 16.4, while in the south it decreased by about 35 at a temperature of 20.8 for the period 1986-2023, and the number began to decrease in the period 2024-2085 due to the high temperatures for the RCP45 scenario, while in a high carbon future RCP85 scenario notes that temperatures are higher than the RCP45 scenario, and therefore the number of mosquito populations decreases. Therefore, the statistical analysis gave a strong inverse correlation. As temperatures increase in the future, *Aedes albopictus* decreases.

ACKNOWLEDGMENTS

Thanks and appreciation to the copernicus services for the good data to cover the event with distinction ,and thanks to everyone who contributed to this work.. A special thank you to the anonymous reviewers for their insightful critiques and edits.

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