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Ecological aspects of the bancroftian filariasis vectors, *Culex pipiens* and *Cx. quinquefasciatus* (Diptera: Culicidae) in Hail, Saudi Arabia

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Abstract
Some of ecological aspects of *Cx. pipiens* and Cx. *quinquefasciatus* were examined in Hail Region, Saudi Arabia. For *Cx. quinquefasciatus,* shade ($P<0.01$) and absence of algae ($P<0.05$) and for Cx. *pipiens,* stagnant water ($P<0.05$) of the breeding habitat seem to be determining factors in occurrence of such species. Both species were common in the middle of Hail. Larval abundance of both species is directly related to water temperature ($P<0.01$) and adult abundance is directly related to weather temperature ($P<0.05$) and inversely related to RH and WV ($P>0.05$). For both species, larvae breed and adults were active all year round with summer and autumn peaks of abundance. Results are of importance in predicting the period of maximum risk of disease transmission and for carrying out an effective control program in this part of the Kingdom that acts as a passage for Muslim pilgrims in their way to Makkah and Al Madinah.

Keywords: Mosquitoes, ecology, *Culex pipiens*, *Cx. quinquefasciatus*, hail, Saudi Arabia

1. Introduction
Fifty three mosquito species of *Anopheles*, *Culex*, *Lutzia*, *Ochlerotatus*, *Stegomyia*, *Aedes*, *Aedimorphus*, *Fredwardsius Culiseta*, *Uranotaenia* and *Orthopodomyia* genera represent the indigenous mosquito fauna of the Kingdom of Saudi Arabia [1]. Although the previous surveys covered most regions of Saudi Arabia, yet as far as we are aware no one dealt with the mosquito fauna of Hail Region. Saudi Arabian mosquitoes play an important role as vectors of diseases mainly filariasis [2, 3], Rift Valley Fever [4, 5], Dengue fever [6, 7], malaria [8], West Nile Virus [9] and Sindbis virus [10].

Of the reported mosquitoes in Saudi Arabia, *Cx.* (*Cux.*) *pipiens* L. (the house mosquito) and *Cx.* (*Cux.*) *quinquefasciatus* Say (the southern house mosquito) are the most common species [11] and were implicated as the chief vectors of bancroftian filariasis, *Wuchereria bancrofti* and West Nile Virus [3, 9, 12].

To control mosquitoes, a good knowledge and understanding of the relevant biology and ecology of the target species is of paramount importance [13, 14]. Understanding of the climatic factors influencing adults and larvae is the first step to control mosquito vector's survival, production, development, abundance and distribution [15]. Moreover, the knowledge of ecological features of the mosquito breeding sites is a potential key element for implementing effective larval control [16, 17], help in designing optimal vector control strategies [18] and to collect information on factors that may determine oviposition, survival, and distribution of important disease vectors [19]. Such ecological features that affect abundance, composition and density of mosquito larvae can be classified into two major parameters, biotic (vegetation and predators) and abiotic (other factors such as shade, turbidity …etc) [20].

Generally, mosquitoes breed in a wide range of habitats with different types of waters. The physical and chemical nature of the water probably determine the selection of the breeding sites [13]. The breeding water quality is an important determinant of whether female mosquitoes will lay their eggs, and whether the resulting immatures will successfully complete their development to adults [19]. It was reported that temperature affects the abundance and activity of mosquitoes; for example high temperature accelerates mosquito development from egg to adult and increases their abundance [21, 22- 25]. The relative humidity strongly affects the number of females laying eggs, the number of eggs laid, feeding frequency, survival, flight and

subsequent host seeking behavior of mosquitoes [26- 28]. Very few studies [15, 25, 29] were carried out in Saudi Arabia to examine the physical and chemical factors mainly temperature, pH and salinity relative to mosquito breeding and effect of temperature, relative humidity and rainfall on adult mosquito abundance. However, no studies were carried out on *Cx. pipiens* and *Cx. quinquefasciatus*, except that of Hassan *et al*. [30, 31] in the western coast.

The seasonal abundance of the prevailing mosquito species was studied in several parts of Saudi Arabia [1, 32-39]. The obtained knowledge is of importance in predicting the period of maximum risk of disease transmission and for carrying out an effective control program.

Due the abundance of *Cx. pipiens* and Cx. *quinquefasciatus* and their medical importance, this study was planned and undertaken to examine the ecological aspects of these two species (relative and seasonal abundance, distribution and effect of weather factors on larval and adult abundance) in Hail Region. This will be of help in predicting the risk period of disease transmission and in planning of control programs.

2. Materials and Methods

2.1 The Study Area

Hail Region (Figure 1) is located in the north-central part of the Kingdom of Saudi Arabia (KSA) (39º "52 ‘26 to º 44 42" 22' E and 34" 16' 25º to 16" 53' 28 N). It is bordered from north by Northern Border and El Jawf, from south by Al Madinah and Al Qasim, from east by Al Qassim and Riyadh and from west by Al Madinah and Tabouk. It has an area of 104000 km² (6.1% of the total Kingdom area) and a population of about 600,000 (2010 census). The region is subdivided into eight governorates (Baqa'a, Al-Ghazalah, Ash-Shnan, Sumaira'a, Mawqaq, Ash-Shamli, Al-Sulaimi and Al-Hayet) in addition to the capital, Hail city and is characterized by two mountains: Aga and Salmi. Hail city (27°31′N 41°41′E) is located in an area of 825-1050 m above sea level and extends in the form of a bow surrounding Samraa mountain and it is bordered from north and west by Aga mountain which reach up to 1490 m above sea level. The city is famous for its agricultural products such as dates, fruits, vegetables, barley and wheat and acts as a passage for Muslim pilgrims from Iraq and Syria in their way to Makkah and Al Madinah. Hail has a continental desert climate with hot summers (average 29.6 °C) and cool winters (10.6 °C); with somewhat milder climate during spring (20.7 °C) and autumn (21.4 °C) than other Saudi cities due to its higher altitude. Seventeen localities were bimonthly surveyed for mosquito adults and larvae (Table 1) for one year from July 2015 to June 2016.

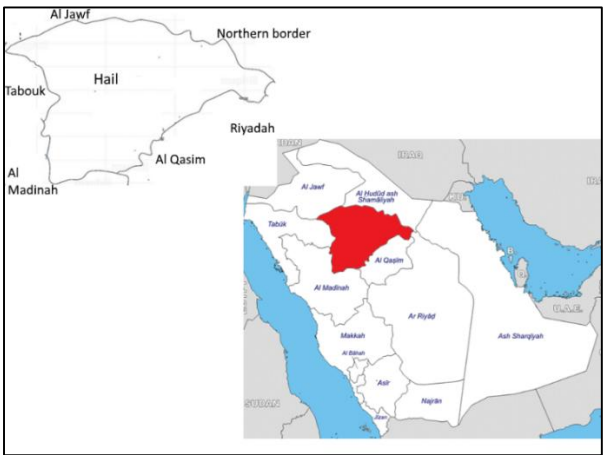

Fig 1: Location of Hail in the north-central part of KSA

Table 1: The Study areas and surveyed localities in Hail, KSA

Area	Locality	Longitude	Latitude	Collection	
				Larvae	Adults
North	Al Yasmin	2735208	4143437	●	●
	Al Swefla	2733199	4145003	●	●
	Mashar	2735712	4140289	●	
	Al Masif	2734350	4140448		●
	Al Khozami	2734141	4143844		●
Middle	AL Zabar	2730660	4142903	●	
	Al Samraa	2730624	4142962	●	
	Al Snaiaa	2728612	4143672	●	
	Al Mogheda	2732102	4141988		●
	Al Mazaer	2731661	4142845		●
	Barzan	2731591	4141916		●
	Al Azizia	2731446	4140179		●
South	Mrefak	2725290	4136054	●	
	Kfar	2723922	4135523	●	●
	Neqra	2728803	4139890	●	●
	Al Shafaa	2726951	413769		●
	Al Rasif	2725643	413557		●

2.2 Collection of mosquito larvae and adults
In each locality, larvae were sampled in the water bodies by dipping using a plastic dipper, 125 mm in diameter with a 90 cm aluminum telescopic handle. Three samples of 10 dips per breeding site were taken. Collected larvae were placed in labeled plastic bags (Nasco whirl pack 4002 filline U.S.A) and transported to the laboratory in a picnic ice box containing cold water to prevent overheating. Adults were collected using V-Mart Super photo-catalyst Black Hole (BH) traps (Venus Technology Co., Ltd. Wangthonglang, Bangkok, Thailand). The traps (5 per locality) were set before sunset and collected after sunrise next morning. The collected mosquitoes were aspirated, placed in labeled paper cups that kept in a picnic ice box while being transported to the laboratory. At the laboratory, 3rd and 4th larval instars and adult samples were preserved in labeled specimen tubes containing 70% ethyl alcohol to be ready for identification using different keys [40- 43].

2.3 Relative abundance and spatial distribution
The compiled relative abundance of each species (% of larvae and adult from total collection) for all localities altogether was calculated and compared by Chi-squared test to examine the more abundant species. The mean monthly collection of larvae and adults of each species in the 3 areas of Hail (north, middle and south) was calculated and compared by one-way ANOVA. If F showed significant inequality of the means, they were further exposed to pairwise comparisons based on Tukey's honestly significant difference (HSD) test. The SSP (Smiths Statistical Package) computerized software [44] was used for such analysis.

2.4 Characteristics of the breeding habitats
Along with larval collections, the natural characteristics of the breeding habitats (presence of algae and vegetations, exposure to sunlight, water movement, and presence or absence of solid wastes, i.e. turbidity) were recorded. The relative abundance (%) of each habitat characteristic and occurrence frequency of each mosquito species (% of total collection) comparable to each character was calculated and analyzed. The 2x2 contingency tables were constructed and chi-squared was calculated to examine the dependence of species occurrence on certain character [44].

2.5 Effect of water temperature on larval abundance and of weather temperature, relative humidity and wind velocity on adult abundance
Along with larval collection, the water temperature was measured in situ. The weather temperature (Temp. ^{o}C) and Relative Humidity (RH%) were measured using 2-in-1 LCD Digital Thermometer Hygrometers Model: TA328 (Lutrun Electronic Inc., Coopersburg, PA, USA). Wind velocity (WV, Km/h) was measured using Digital Anemometer Model: AM-4203 (Lutrun Electronic Inc., Coopersburg, PA, USA). Simple Regression analysis was used to examine the relation of larval abundance (No collected) with water Temp. Multiple Regression analysis was used to examine the relation of adult abundance (No collected) with Temp., RH and WV. The slopes (regression coefficients, b) of the regression equations were tested for deviation from 0 by t-test [44]. The Correlation coefficient (R) that representing the total variance in abundance of two species was calculated as $\sqrt{R^2}$ (Coefficient of determination).

2.6 Seasonal abundance
The monthly and seasonal percentages of larvae and adults from the total collection of the one year study period were calculated to examine the seasonal abundance of the two species.

3. Results
3.1 Relative abundance
A total of 1270 adult and 883 larva of the two species were collected during the study period of which ***Cx.*** *quinquefasciatus* was more common (55.91%, $\chi 2 = 2.88$, $P>0.05$) than *Cx. pipiens* (44.09%) as adults, and *Cx. pipiens* was more common (50.17%, $\chi 2 = 0.00$, $P>0.05$) than *Cx. quinquefasciatus* (49.83%) as larvae. The two species were encountered in the three parts of Hail (north, middle and south). Comparison of monthly mean collection of the two mosquito species in the three parts (Table 2) indicated that both *Cx. quinquefasciatus* (larvae: F= 0.44, $P>0.05$; adults: F= 3.67, $P<0.05$) and *Cx. pipiens* (larvae: F= 5.76, $P<0.05$; adults: F= 0.64, $P>0.05$) were more common in the middle part than in the other two parts. Further comparison by HSD test indicated that *Cx. quinquefasciatus* adults and *Cx. pipiens* larvae were more common ($P<0.05$) in the middle part than in the other parts of Hail.

Table 2: Monthly mean collection of larvae and adults of the two mosquito species in the three parts of Hail

Species	Part	Mean /Month[1,2]	
		Larvae	Adult
Cx. quinquefasciatus	North	14.17	14.50^{B}
	Middle	12.08	27.83^{A}
	South	10.42	17.67^{B}
Cx. pipiens	North	06.50^{B}	13.58
	Middle	18.75^{A}	18.67
	South	10.83^{B}	14.42

1. SD's were omitted.
2. In each column, means with different letters are significantly different, Turkey's HSD test, $P<0.05$.

3.2 Types and characteristics of the breeding habitats
Several types of breeding habitats (Figure 2) were examined. Certain characteristics of the breeding habitats were insignificantly ($P>0.05$) more common than the others (Table 3). These were: presence of shade, algae, vegetations, stagnant water and turbidity (solid wastes). It was found that shade ($P<0.01$) and absence of algae ($P<0.05$) of the breeding habitats seem to be determining factors in the occurrence of *Cx. quinquefasciatus* ($P<0.01$) while *Cx. pipiens* occurs more frequently in sunny (51%, $P>0.05$) than in shaded sites and in the absence of algae (59%, $P>0.05$) than in its presence. Stagnant water seems to be a determining factor in breeding of *Cx. pipiens* ($P<0.05$) while *Cx. quinquefasciatus* breeds more frequently (52%, $P>0.05$) in moving than in stagnant water. The two species insignificantly ($P>0.05$) preferred presence of vegetation. *Cx. quinquefasciatus* is indifferently ($P>0.05$) breeding in water have solid wastes or devoid of it while *Cx. pipiens* prefers breeding in turbid water (59%, $P>0.05$).

3.3 Relation of larval abundance with water temperature
The results of simple regression analysis (Table 4) indicated that larval abundance (No collected) of both *Cx.*

quinquefasciatus (b=1.31, t=3.63, *P*<0.01) and *Cx. pipiens* (b=1.70, t=4.01, *P*<0.01) is directly related to water temperature. The R's (Correlation coefficients) were 0.75 (*Cx. quinquefasciatus*) and 0.78 (*Cx. pipiens*).

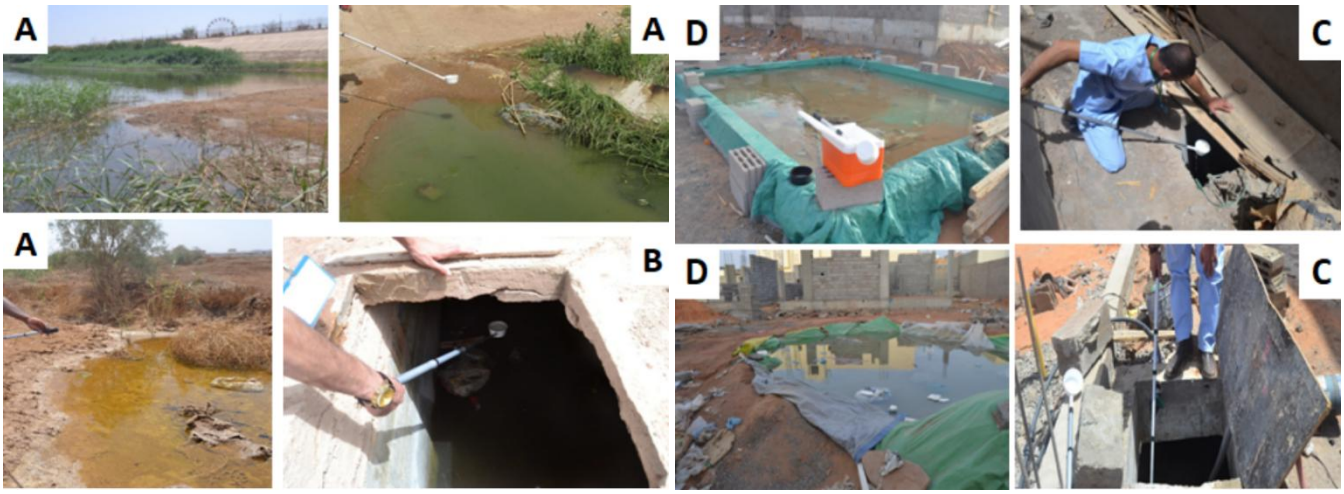

Fig 2: Examples of breeding sites A: seepage water, B: Septic tank, C: underground water reservoir, D: Surface water reservoir used for under construction buildings

Table 3: Relative abundance (%) of the breeding habitat characteristics in Hail and occurrence percentages of mosquito larvae in relation to the characteristics of the breeding habitats.

Characters	Breeding place (n= 86)	Occurrence frequency (%)[a]	
		Cx. *Quinquefasciatus* (n= 48)	*Cx. Pipiens* (n= 49)
Shade: Shaded / Sunny	52.33/47.67	62.50/37.50**	48.98/51.02
Algae: Present / Absent	59.30/40.70	39.58/60.42*	40.82/59.18
Vegetations: Present / Absent	56.98/43.02	58.33/41.67	53.06/46.94
Movement: Moving / Stagnant	41.86/58.14	52.08/47.92	38.78/61.22*
Turbidity: Present / Absent	52.33/47.67	50.00/50.00	59.18/40.81

*P<0.05, **P<0.01; Chi-squared test.

3.4 Relation of adult abundance with weather conditions

The two species were found to have the same ranges of Temp. (5.00-37.00 °C), RH (23.00-60.00%) and WV (8.50-14.68 km/h). The results of multiple regression analysis (Table 4) indicated that abundance (No collected) of (1) *Cx. quinquefasciatus* (b= 1.73, t= 2.01, *P*<0.05) and *Cx. pipiens* (b= 2.73, t= 1.93, *P*<0.05) is directly related to Temp. (2) *Cx. quinquefasciatus* (b=-1.05, t=1.42, *P*>0.05) and *Cx. pipiens* (b=-0.52, t=0.39, *P*>0.05) is inversely related to RH (3) both species (*Cx. quinquefasciatus*: b=-0.61 and *Cx. pipiens*: -3.72, *P*>0.05) is inversely related to WV. The R's (correlation coefficients) were 0.92 (*Cx. quinquefasciatus*) and 0.77 (*Cx. pipiens*).

Table 4: The b (slope, Regression coefficient) and R (Correlation coefficient) values of regression analysis for the effect of temperature (Temp.), relative humidity (RH) and wind velocity (WV) on the abundance of the two mosquito species

Stage	Species	b[1] (Regression coefficient)			R (Correlation coefficient)
		Temp.	RH	WV	
Larvae	*Cx. quinquefasciatus*	1.31*			0.75
	Cx. pipiens	1.70*			0.78
Adults	*Cx. quinquefasciatus*	1.73*	-1.05*	-0.61	0.92
	Cx. pipiens	2.72*	-0.52	-3.72	0.77

*P<0.05, t-test

3.5 Seasonal Abundance

The seasonal abundance of the two species was investigated based on percentage of larvae and adults from total collection (Figure 3) and results revealed that: (1) larvae were found breeding more during summer (34.09% for *Cx. quinquefasciatus* and 30.47% for *Cx. pipiens*) and autumn (32.95% for Cx. *quinquefasciatus* and 41.76% for *Cx. pipiens*) than during spring (20.45% for Cx. *quinquefasciatus* and 15.35% for *Cx. pipiens*) or winter (12.51% for *Cx. quinquefasciatus* and 12.42% for *Cx. pipiens*). Higher breeding of *Cx. quinquefasciatus* was during July (15.91%) and November (13.64%) and that of *Cx. pipiens* was observed during August (15.80%) and November (14.67%), and (2) Similarly, adults were more active during summer (35.35% for Cx. *quinquefasciatus* and 26.07% for *Cx. pipiens*) and autumn (34.37% for Cx. *quinquefasciatus* and 46.96% for *Cx. pipiens*) than during spring (22.25% for Cx. *quinquefasciatus* and 15.54% for *Cx. pipiens*) or winter (8.03% for Cx. *quinquefasciatus* and 11.43% for *Cx. pipiens*). Higher activity of *Cx. quinquefasciatus* was during August (12.96%), September (13.52%) and November (12.82%) and that of *Cx. pipiens* was observed during October (15.81%) and November (21.25%).

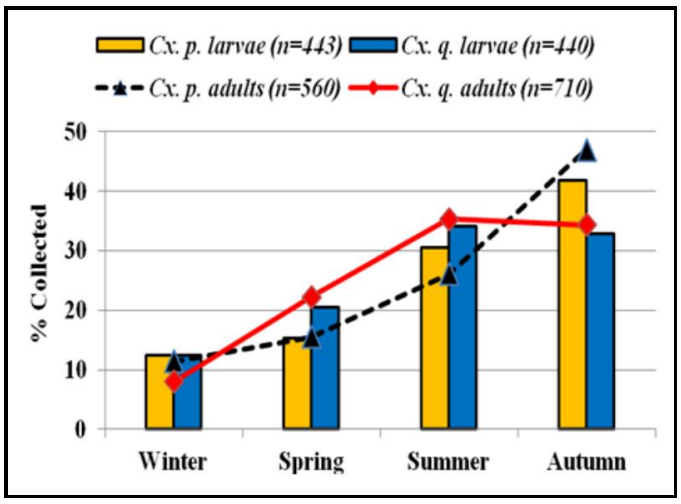

Fig 3: Seasonal abundance of *Cx. pipiens* (*C.p.*) and *Cx. quinquefasciatus* (*C.q.*) in Hail (compiled result of all areas)

4. Discussion

In our collection, adults of *Cx. quinquefasciatus* were more common (P>0.05) than those of *Cx. pipiens* (44.09%). Similarly, in western coast of Kingdom the two species respectively represented 57.52% and 27.42% of the collected mosquitoes [11] and in Makkah, *Cx. quinquefasciatus* was predominating (99.3%) [45]. However in El Madinah Region, *Cx. pipiens* was more common (59.3%) than *Cx. quinquefasciatus* (22.1%) [9]. Larvae of *Cx. pipiens* were more common (P>0.05) than those of *Cx. quinquefasciatus* in agreement with the previous observations in Astir [1, 43] where *Culex pipiens* was the most abundant of all collected larvae. The two species were more common in middle than in northen and southern parts of Hail. This may be due to that this part is mainly an agricultural area and has a wide range of building construction which provides plenty of mosquito breeding habitats.

Generally, mosquitoes breed in a wide range of habitats with different types of waters. The physical and chemical nature of the water probably determines the selection of the breeding sites [13]. It was reported [19] that breeding water quality is an important determinant of whether female mosquitoes will lay their eggs, and whether the resulting immature stages will successfully complete their development to the adult stage. In this study, the presence of shade, algae, vegetations, stagnant water and turbidity (solid wastes) were the common characteristics of the breeding habitats (P>0.05). Breeding habitats that are shaded and devoid of solid wastes and have stagnant water and aquatic vegetations were significantly common in two localities of Cairo Governorate, Egypt [20].

The knowledge of the natural characteristics of the mosquito breeding habitats is important for implementing effective larval control program. For this, the association of *Cx. pipiens* and *Cx. quinquefasciatus* with the physical characteristics of their breeding habitats was examined. The preference of *Cx. pipiens* for stagnant water is in agreement with the observations in Egypt [20, 46, 47]. It was reported that the effect of sunlight or shade varies depending on the mosquito species and the favorable effect of sunlight on mosquito larval population is to the requirement of algae (favorable larval food) to sunlight [48]. Horsfall [49] pointed out that light is not essential for development of *Cx. fatigans* (*quinquefasciatus*) and *Cx. pipiens*. In this study, shade seems to be a determining factor in the occurrence of *Cx. quinquefasciatus* (P<0.01) while *Cx. pipiens* occurs more frequently (P>0.05) in sunny than in shaded sites. Almost similar results were obtained in Asir region [1]. In some parts of Egypt for examples: in Cairo, *Cx. pipiens* was indifferentially breeding (P>0.05) in shaded and sunny sites [20] and in El-Sharkiya Governorate [46], larvae of *Cx. pipiens* prefer shaded habitats (P<0.05).

Turbidity of the breeding water may partially due to the presence of solid wastes. It was indicated [17] that in turbid breeding sites, culicine larvae are much more likely to be present. In this study, *Cx. quinquefasciatus* is indifferently breeding in water that has solid wastes or devoid of it while *Cx. pipiens* prefers breeding in turbid water. Similarly, water turbidity (due to suspended matters) significantly affected breeding of *Cx. pipiens* (P<0.05) [46].

The presence of floating plants and algae provide optimal breeding conditions for mosquito larvae by acting as food sources, shelter from predators and creates stagnant conditions by decreasing water movement [50] and offering newly emerged adults and gravid mosquitoes a shaded resting sites [51]. In this study, the two species preferred absence of algae and presence of vegetation (P>0.05). Similarly, reports [14, 52, 53, 54, 55] indicated a positive association between mosquito larvae and the presence of vegetation. However, Matthys *et al*. [56] reported that water surfaces abundantly covered by floating vegetation result in reduced mosquito larval densities because of shadowing by the vegetation cover.

The simple regression analysis was used to examine the relation of larval abundance with the temperature and results indicated that abundance of both species is directly related to temperature (P<0.01) in agreement with the observations in western coast, where densities of *Cx. pipiens* (b =1.96, P>0.05) and *Cx. quinquefasciatus* (b = b = 2.64, P<0.05) [30] were directly related to temperature. However, in the Eastern Province, mosquito larval abundance has a negative correlation with temperature [15]. The obtained R's indicated that 75% and 78% of the variance in abundance of *Cx. quinquefasciatus* and *Cx. pipiens*, respectively and that the remaining 25% and 22% of the variance, respectively may be attributed to other factors related to other characteristics of the breading sites. In a similar study [15], regression model of the three climatic factors (temperature, relative humidity and rainfall) accounted for 64.3% of the variance in larval abundance and the remaining 35.7% attributed to other factors such as the presence of vegetation, waste materials and water reservoirs such as ditches.

In the present study adults of *Cx. pipiens* and *Cx. quinquefasciatus* had the same ranges of Temp., RH and WV similar to the case in the western coast of Saudi Arabia [31] where the two species had the same ranges of Temp. (15.00-30.00 °C), RH (8.00-72.00%) and WV (0.10-8.06 Km/h). This indicates that these species can withstand a wide range of weather conditions. There was no study examining the effect of such weather factors on abundance of these two species in Hail. Regression analysis indicated that abundance of the two species directly related to Temp. (P<0.05), and inversely related to RH and WV (P>0.05). However, abundance of the same species in the western coast negatively related to Temp. and WV and positively related to RH [31]. Such difference may be attributed to the difference in ranges of the three factors in Hail and western coast. Moreover, it was found that in six

localities of the Eastern Province, a strong negative correlation between mosquito abundance and Temp. (R=-0.87) and a strong positive correlation with RH (R=0.65) [15]. The obtained R values indicated that 0.77 and 0.92% of the total variance in abundance of *Cx. pipiens* and *Cx. quinquefasciatus*, respectively were accounted, in agreement with observation in western coast for the same factors (81% for *Cx. pipiens* and 76% for *Cx. quinquefasciatus*) [31]. Similarly, in the Eastern Province, 84.5% of variance was observed for the effect of Temp., RH and rainfall on mosquito abundance of three genera (*Culex*, *Aedes* and *Anopheles*) [15]. The remaining 23% (*Cx. pipiens*) and 8% (*Cx. quinquefasciatus*) of the variance encountered in present study may be attributed to other factors mainly rainfall which had moderate positive correlation (R=0.15) with mosquito abundance [15] and is considered the most significant variable influencing anopheline density [57].

The knowledge of the seasonal activity of mosquitoes is of importance in predicting the period of maximum risk of disease transmission and for carrying out an effective control program. Due the abundance of *Cx. pipiens* and *Cx. quinquefasciatus* and their medical importance, this study was planned to examine their seasonal abundance based on percentages of larvae and adults from total collection. It was found that *Cx. pipiens* and *Cx. quinquefasciatus* larvae breed and adults were active all year round with summer and autumn peaks of abundance, i.e. during seasons with higher mean temperature (31 - 35ºC) and lower RH (24-33%) than during the other seasons with lower temp (11-24 ºC) and higher RH (35-51%). Regression analysis explained such seasonality as abundance of the two species larvae increase as temperature increases and that of adults decrease as RH increases. In the western coast [38], larvae of *Cx .pipiens* have peaks of abundance in autumn and high breeding in summer, while those of *Cx. quinquefasciatus* larvae have winter peak and high breeding in spring. Adults of the two species have general peaks of abundance during spring with higher activity during autumn and winter than during summer. The obtained results are of importance in predicting the period of maximum risk of bancroftian filariasis, *Wuchereria bancrofti* and West Nile Virus transmission of which the two species act as vectors and for implementing an effective control program. In some other parts of the Kingdom, the seasonal abundance of some mosquito adults was investigated. In Makkah Region, mosquitoes were collected throughout the year with two peaks in June and December when temperature was 31 and 35ºC, respectively [32]. Mahyoub *et al*. [33] pointed out that *Culex* genus fluctuated throughout the year and was found to make three or four peaks. In Ar Riyadh City, *Cx. quinquefasciatus* adults and three other species were collected with the high numbers were during December and April when temperature and humidity were optimum, while during summer and winter numbers were low [34]. larvae of *Culex* species in Astir were found with peaks of abundance during spring [1].

5. Conclusion

Due to the abundance, seasonality and medical importance of *Cx. pipiens*, and *Cx. quinquefasciatus* as vectors of bancroftian filariasis and West Nile Virus may pause a threat of transmission of such diseases in this important part of the Kingdom that acts as a passage for Muslim pilgrims in their way to Makkah and Al Madinah. The results may be of help in predicting the period of maximum risk of disease transmission and carrying out an effective control program. It worth to mention that not only the type of breeding habitat but also its natural characteristics that affect the occurrence of such two mosquito species in a certain habitat. So that environmental control measures based on modifying habitat characteristics can be effective in controlling such mosquito species.

6. References

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