INSECT ECOLOGY

Influence of climatic factors on the abundance of *Culex pipiens* and *Cx. quinquefasciatus* (Diptera: Culicidae) adults in the Western Coast of Saudi Arabia

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**Abstract**

This study aims to examine the effect of weather factors, temperature (T), relative humidity (RH) and wind velocity (WV) on the abundance of *Cx. (Cux.) pipiens L.* and *Cx. (Cux.) quinquefasciatus* Say, the two common and important mosquito species in the western coast of Saudi Arabia. The two species had the same ranges of T (15.00-30.00°C), RH (8.00-72.00%) and WV (0.10-8.06 Km/h). *Cx. quinquefasciatus* had insignificantly (P˃0.05) lower means of the three factors than those of *Cx. pipiens*. Regression analysis indicated that abundance of *Cx. pipiens* and *Cx. quinquefasciatus* negatively related to T (regression coefficient, b=-0.06 and -0.01 for the two species, respectively) and WV (b=-0.40 and -0.16 for the two species, respectively) and positively related to RH (b=0.05 for both species). Such factors accounted for 81% and 76% of the variance in abundance of *Cx. pipiens* and *Cx. quinquefasciatus* respectively while the remaining parts (19% and 24% for the two species, respectively) may be attributed to other factors mainly rainfall.

**Introduction**

Thirty two mosquito species belonging to 7 genera are indigenous in the western part of the Kingdom: 14 Anopheles, 12 Culex, 2 Ochlerotatus, and 1 species each of Lutzia, Stegomyia, Culiseta and Uranotaenia (Ai-Ali et al., 2008; Al-Ghamdi et al., 2008; Alahmed et al., 2009; Kheir et al., 2010; Al Ahmad et al., 2011; Khater et al., 2013; Alkhant et al., 2014; Mahyoub et al., 2015). In a recent survey in the western coast (Hassan et al., 2016b), 19 species were identified of which *Cx. pipiens* (22.4% larvae, 27.42% adults) and *Cx. quinquefasciatus* (47.11% larvae, 57.52% adults) were the common species. The two species are the chief vectors of bancroftian filariasis, *Wuchereria bancrofti* in many parts of the world including the Middle East and Eastern Mediterranean countries (Ai-Ali et al., 2008; Samy et al., 2016). Omar (1996) reported that *Cx. pipiens* may act as a potential vector of introduced bancroftian filariasis to Saudi Arabia. In addition, *Cx. pipiens* and *Cx. quinquefasciatus* act as vectors of West Nile Virus (Al-Ali et al., 2008; Samy et al., 2016).

To control mosquitoes, a good knowledge and understanding of the relevant biology and ecology of the target species is of paramount importance (Seghal & Pillai, 1970; Gimnig et al., 2001). Understanding climatic factors (temperature, relative humidity and rainfall) influencing adults and larvae is the first step to control over mosquito vector survival, production, development, abundance and distribution (Jemal & Al-Thukair, 2016). Temperature and rainfall were found to be closely associated with mosquito density (Tian et al., 2015). The temperature affects the abundance and activity of mosquitoes; for example high temperature accelerates mosquito development from egg to adult and increases their abundance (Tun-Lin et al., 2000; Hopp & Foley, 2001; Bayoh & Lindsay, 2003; Alahmed, 2012; Alshehri, 2013).

However, it was reported that temperature greater than 30°C decreases mosquito survivorship and abundance (Westbrook et al., 2010; Christiansen-Jucht et al., 2014). The relative humidity is often increased by rainfall, particularly following drought and...
strongly affects the number of females laying eggs, the number of eggs laid, feeding frequency, survival, flight and subsequent host seeking behavior of mosquitoes (Day & Curtis, 1989; Reiter, 2001; Ceccato et al., 2005). Different studies have indicated that high RH increases mosquito lifespan, hatching, density, survival and abundance (Hopp & Foley, 2001; Reiter, 2001; Murty et al., 2010; Alahmed, 2012; Alshehri, 2013; Tian et al., 2015). Moreover, rainfall and RH were the most significant influencing anopheline density but the effects of temperature were not found as a significant variable on the abundance of anopheline mosquitoes in Bangladesh (Bashar & Tuno, 2014).

Very few studies were carried out in Saudi Arabia to examine the effect of climatic factors (temperature, relative humidity and rainfall) on mosquito abundance; these studies considered the dengue vector Stegomyia aegypti (Al-Ghamdi et al., 2009; Alshehri, 2013) above all. Jemal & Al-Thukair (2016) examined the effect of these factors on mosquito abundance of three genera (Culex, Aedes and Anopheles) in the Eastern Province. However, no studies were carried out on Cx. pipiens and Cx. quinquefasciatus adults, this study was planned and aimed at examining the effect of the climatic factors (temperature, relative humidity and wind velocity) on abundance of these two common and important mosquito species in the western coast.

Materials and Methods

The study area

The Western part of the Kingdom of Saudi Arabia (16° and 33°N, 34° and 56° E) includes the west coast north of Asir. It contains a mountain chain (with peaks rising to 3000 meters) and the coastal plain bordering the Red Sea. It also includes the most cosmopolitan city of Jeddah which is the main port for thousands of pilgrims on their trip to Holy Cities of Mecca (to the east) and Al Madinah (to the north). In the mountains above Mecca and Jeddah is the town of Taif. Its elevation gives it a climate far cooler than either Jeddah or Mecca and without the uncomfortable humidity of these two cities. The coastal area of the Western part (1090 km long) is notorious for its humidity, with summer temperatures rising to above 40°C. Three regions representing this part: Mecca “21°25′N 37°0′E”, Taif “21°26′N 40°21′E” and Mecca: “21°30′N 41°0′E”.

The study was carried out in four sea ports (Jeddah: 21°32′36″N 39°10′22″E, Yanbu: 24°05′N 38°00′E, Duba: 27°20′57.3″N 35°41′46.2″E and Haql: 29°17′N 34°56′E) and two cities (Taif: 21°26′N 40′21′E and Mecca: 21°30′N 41°0′E) representing the three regions (Figure 1). In each locality, certain sites were selected and biweekly surveyed for mosquitoes during the period from January 2013 to December 2014.

Mosquito sampling

Adults were collected using three different types of traps: i) the CDC (Center for Disease Control) miniature light traps (Model 512, John W. Hock Co., Gainesville, FL, USA), ii) V-Mart Super photo-catalyst Black Hole (BH) traps (Venus Technology Co., Ltd. Wangthonglang, Bangkok, Thailand) and iii) UV traps (John W. Hock Company, Gainesville, FL, USA). The traps 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. In the laboratory, mosquitoes were preserved in 70% alcohol till identification to the species level according to keys of Mattingly & Knight (1956) and Harbach (1985; 1988).

Results

Ranges of the weather temperature, relative humidity and wind velocity

The ranges of the weather T, RH and WV were determined for Cx. pipiens and Cx. quinquefasciatus and results (Table 1) revealed that the two species had the same ranges of T (15.00-30.00°C), RH (80.00-72.00%) and WV (0.10-8.06 Km/h). Cx. quinquefasciatus had insignificantly (P>0.05) lower means of T (25.20°C), RH (36.63%) and WV (2.24 Km/h) than those of Cx. pipiens (25.53°C, 38.36% and 2.33 Km/h for the 3 factors, respectively).

Relation of mosquito abundance with the temperature, relative humidity and wind velocity

The results of multiple regression analysis (Table 2) indicate that: i) abundance of Cx. pipiens (b=-0.06, t=1.09, P>0.05) and Cx. quinquefasciatus (b=-0.01, t=0.13, P>0.05) is inversely related to
T, i.e. decreases as T increases, ii) abundance of *Cx. pipiens* (b=0.05, t=1.92, P<0.05) and *Cx. quinquefasciatus* (b=0.05, t=1.12, P>0.05) is directly related to RH, i.e. increases as RH increases, iii) abundance of *Cx. pipiens* (b=-0.40, t=1.54, P>0.05) and *Cx. quinquefasciatus* (b=-0.16, t=0.32, P>0.05) is inversely related to WV, i.e. decreases as WV increases.

### Discussion and Conclusions

In the present study, *Cx. pipiens* and *Cx. quinquefasciatus* had the same ranges of T (15.00-30.00°C), RH (8.00-72.00%) and WV (0.10-8.06 Km/h). No comparable results for these two mosquito species in the study area or in any other area of the Kingdom were available. In the Eastern Province, Jemal & Al-Thukair (2016) determined the effect of T, RH and rainfall on mosquito abundance of 3 genera (*Culex, Aedes* and *Anopheles*) and showed that T of 15-27°C and RH between 4% and 69% favors the high abundance and spread of the adult mosquitoes and that T greater than 35°C in summer season is unsuitable for adult mosquito growth. Similarly, in Jeddah city, T range from 20°C to 29°C favors the increase in *Aedes aegypti* density and during summer months the average T is more than 40°C which is not suitable for rapid mosquito growth (Alshehri, 2013). Christiansen-Jucht et al. (2014) indicated that higher environmental temperatures (than 30°C) significantly lower adult survival and increase adult mortality (P<0.001), however it was reported that high T speeds up mosquito growth and increases mosquito abundance (Tun-Line et al., 2000; Hopp & Foley, 2001; Alahmed, 2012). Other authors (Bayoh & Lindsay, 2003; Tan et al., 2015) indicated that temperatures of 20-29°C are favorable for mosquito growth and development. Abdel-Hamid et al. (2011b) in El Ismailia Governorate, Egypt, found that both *Cx. pipiens* and *Cx. antennatus* had T range of 16-22.7°C and RH range of 43.8-73.9%.

Regression analysis indicated that abundance of the two species insignificantly (P>0.05) decreases as both T and WV increase and abundance increases as RH increases. Such result reflects the seasonality trends of these two species. In a concurrent study (Hassan et al., 2016a), adults of the two species were active all year round with peaks of abundance during spring, i.e. during the mild temperature (mean≈26°C) and RH (mean≈48%). High activity was also observed during autumn (≈28°C, 50% RH) for

**Table 1. Ranges and means of the weather temperature (T), relative humidity (RH) and wind velocity (WV) for the two common mosquito species.**

<table>
<thead>
<tr>
<th>Attribute</th>
<th><em>Cx. pipiens</em></th>
<th><em>Cx. quinquefasciatus</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>T (°C)</td>
<td>15.00-30.00</td>
<td>15.00-30.00</td>
</tr>
<tr>
<td>RH (%)</td>
<td>8.00-72.00</td>
<td>8.00-72.00</td>
</tr>
<tr>
<td>WV (Km/h)</td>
<td>0.10-8.06</td>
<td>0.10-8.06</td>
</tr>
</tbody>
</table>

**Table 2. Multiple regression analysis for the effect of temperature (T), relative humidity (RH) and wind velocity (WV) on the abundance of the two common mosquito adults.**

<table>
<thead>
<tr>
<th>Species</th>
<th>b (regression coefficient)</th>
<th>R (correlation coefficient)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Cx. pipiens</em></td>
<td>-0.06</td>
<td>0.81</td>
</tr>
<tr>
<td><em>Cx. quinquefasciatus</em></td>
<td>-0.01</td>
<td>0.76</td>
</tr>
</tbody>
</table>
and a direct relation with RH. Such factors accounted for 81% and 76% of the variance in abundance of Cx. pipiens and Cx. quinquefasciatus, respectively, while the residual variance may be attributed to other factors mainly rainfall.

References


