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Analysis of the interspecific association between *Culex pipiens* and *Cx. perexiguus* mosquito larvae (Diptera: Culicidae) in two urban environments of Cairo, Egypt

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ABSTRACT

Mosquito surveys of two urban localities in Cairo (El-Muqattam and Abu-Seir) were undertaken for one year. The extent of interspecific association between the two common species: *Culex pipiens* and *Cx. perexiguus* was measured on the basis of presence-absence data and on their relative numbers. The two species had a significantly slight/ moderate association (C= 0.19-0.35 and C_{AB}= 0.50-0.54, P<0.001). The values of Sorensen's coefficient (I) indicated high association in El-Muqattam (0.88) and moderate association in Abu-Seir (0.47) or the two localities altogether (0.53). Such coefficient showed monthly variation and was directly related to the separate/ compiled densities of the two species (b= 0.01-0.02) in El-Muqattam (P>0.05), Abu-Seir and the two localities (P<0.05). The obtained results indicate that the requirements of the two species are similar and that their larval densities influencing the degrees of their interspecific association.

INTRODUCTION

The association between two species is the tendency of a species to influence the distribution of another one. The co-existence of mosquito larvae in the same breeding places may be common. However, this does not necessitate that the species are in interspecific relations or associations. Several measurements for such an association were developed and reviewed by Service (1976) and Southwood (1991). Unfortunately, most of these measurements are influenced by the size of the sampling unit / collection and by the distribution pattern of the two species in the area. The methods of assessing the extent to which two species occur together are based either on the presence-absence data or on the abundance figures of the concerned species. The presence-absence data is preferable if it is desired to measure the extent to which two species' requirements are similar. Interspecific competition (and other factors) may lead to a "misleading" lack of association if the measure is based on abundance data.

Few reports are available on mosquito association in Egypt (Kirkpatrick, 1925; Margalit and Tahori, 1973; El-Said *et al.*, 1983 and Kenawy, 1990) that dealt mainly with the frequency of joint occurrence among the different species. The quantitative evaluation of the association among the Egyptian mosquitoes specially the common ones is needed. This is of importance for further understanding of their ecology particularly in respect to similarity in their breeding habitats requirements.

The present study examines and quantifies the co-breeding of *Cx. pipiens* and *Cx. perexiguus* in a range of habitats prevailing in two urban localities in Cairo Governorate. The two species are common and of medical importance in Egypt. *Culex pipiens* is considered the major vector of filariasis (Harb *et al.*, 1993) while *Cx. perexiguus* is one of the potential vectors of Rift Valley Fever virus (Turell, 1996). The study aimed at evaluating the different forms and degrees of association between the two species and examining the effect of their seasonal abundance upon the degrees of their interspecific association.

MATERIALS AND METHODS

The Study Localities

The present study was carried out in two localities representing different levels of urban planning in Cairo Governorate (Fig. 1) namely El- Muqattam in southeast of Cairo (30° 21′ 21"- 29° 58' 52" N and 31° 20′ 52"- 31° 16′ 1" E) and Abu-Seir in northeast of Cairo (30° 10′ 43"- 30° 09′ 11 N and 31° 23′ 56"- 31° 22′ 11" E). El-Muqattam is considered as a planned area as it is upgraded by outlines, plots and schemes of land division and requirements of planning and construction, but some parts of it is considered as unsafe because it lacks a piped sewage system. Abu-Seir is considered as unplanned unsafe area according to the National slum upgrading policy criteria (Ammar *et al.*, 2012).

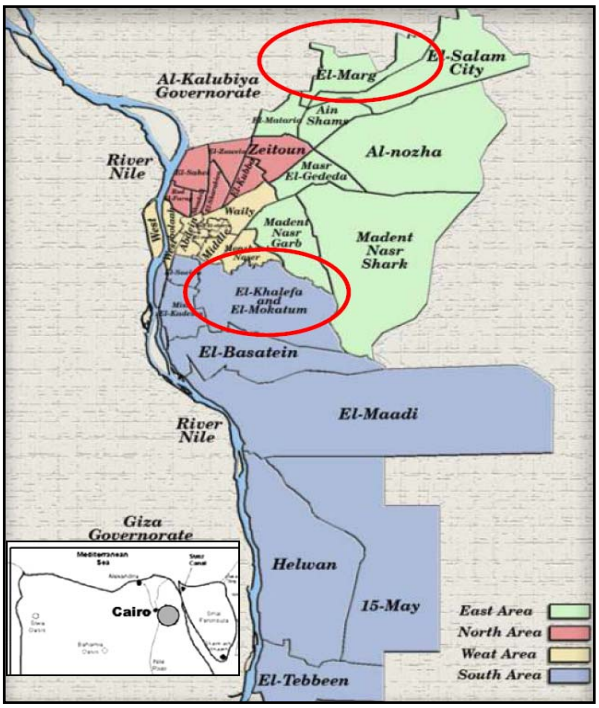

Fig. 1: The study localities in Cairo Governorate

Collection of Mosquito Larvae

In the two localities, 37 sites representing five types of breeding habitats: spring, cesspit, cesspool, irrigation ditch and drainage canal were monthly inspected (Nov. 2009 to Oct. 2010) for mosquito larvae.

Larvae were collected using a standard plastic dipper, 125 mm. in diameter with a 900 mm. wooden handle. Collected larvae were placed in labeled plastic bags and transported to the laboratory where 3rd and 4th larval instars were identified according to the Keys of Harbach (1985).

Measurement of Interspecific Association

The method of Fager (1957) as detailed by Southwood (1991) was used to explain the independence or association of *Cx. pipiens* and *Cx. perexiguus*. Based on the presence-absence data (the occurrence frequencies of the two species), a two by two contingency table was drawn up with the most abundant species, *Cx. pipiens* occupying cells (a) and (c) in the table (Fig. 2A), then tested by the corrected chi-squared (Fig. 2B). If significant chi-squared was obtained then the Coefficient of Contingency (*C*, Fig. 2C) and Coefficient of Interspecific Association ($C_{AB} \pm SD$, Fig. 2D) were computed to give an actual quantitative value for the degree of association. Based on the abundance data (number of larvae), the Index of association (*I*) or Sorensen's coefficient as modified by Southwood (1991) was calculated (Fig. 2E). The values of coefficients (*C*, C_{AB} and *I*) are ranging from -1 (no association) to +1 (complete association).

(A) Contingency table

Cx. perexiguus	*Cx. pipiens* Present (+ve)	*Cx. pipiens* Absent (-ve)	Total
Present (+ve)	a	b	a + b
Absent (-ve)	c	d	c + d
	a + c	b + d	a + b + c + d = n

(B)

$$\chi^2 = \frac{n\,[\,|ad - bc| - n/2\,]^2}{(a+c)\,(b+d)\,(a+b)\,(c+d)}$$

(C) Coefficient of Contingency

$$C = \sqrt{\frac{\chi^2}{n + \chi^2}}$$

(D) Coefficient of Interspecific Association

$$C_{AB} \pm SD = \frac{ad - bc}{(a+b)\,(b+d)} \pm \sqrt{\frac{(a+c)\,(c+d)}{n\,(a+b)\,(b+d)}}$$

(E) Index of association (Sorensen's coefficient)

$$I = 2\left[\frac{J}{A+B} - 0.5\right]$$

Where:
J = Number of larvae of the two species present together.
A = The total larvae of species *A* in all collections.
B = The total larvae of species *B* in all collections.

Fig. 2: Equations for measurement of the interspecific association

The monthly estimates of Sorensen's coefficient (*I*) and compiled larval density of the two species were plotted and curves were smoothed by calculating the weighted moving averages by the formula $a + 2b + c / 4$ (Spiegel, 1961) which gives the average

for 3 consecutive months and where (*b*) is the density/ coefficient of the concerned month, (*a*) is the density/ coefficient of the preceding month and (*c*) is the density/ coefficient of the following month. To examine the relation of the larval densities to (*I*) coefficient, simple regression analysis of the form $y= a +bx$ (Hammer *et al.*, 2001) was used where (y) is the larval density, (*a*) is the intercept (constant), (*b*) is the slope or regression coefficient and (*x*) is the *I* coefficient. The slopes were tested for deviation from zero by t-test.

RESULTS

Relative Abundance of Mosquito Larvae

In 564 collections over the year period a total of 17053 larva of six species were collected from the two localities of which *Culex* (*Culex*) *pipiens* Linnaeus was the most common (77%) followed by *Cx.* (*Cux.*) *perexiguus* Theobald (17%) while the other four species: *Cx.* (*Barraudius*) *pusillus* Macquart, Ochlerotatus (Ochlerotatus) *caspius* (Pallas), *Culiseta* (*Allotheobaldia*) *longiareolata* (Macquart) and *Anopheles* (*Cellia*) *multicolor* Cambouliu were uncommon (totally, 6%). For this the interspecific association was examined only for *Cx. pipiens* and *Cx. perexiguus*, the two common species.

Interspecific Association between *Cx. pipiens* and *Cx. perexiguus*

Based on the presence-absence data (Table 1), the two species had a significantly slight/ moderate association (C= 0.19-0.35 and C_{AB} = 0.50-0.54) in El-Muqattam, Abu-Seir and in the two localities together (P <0.001).

Table 1: Analysis of the interspecific association between *Cx. pipiens* and *Cx. perexiguus* based on their frequencies of occurrence

Locality	*Cx. perexiguus*	*Cx. pipiens*			$\chi^2_{(1)}$	$C^{‡‡}$	$C_{AB} \pm SD^{‡‡‡}$
		+ ve	- ve	Total			
El-Muqattam	+ ve	120	10	130	24.86‡	0.35	0.54±0.10
	- ve	30	20	50			
	Total	150	30	180			
Abu-Seir	+ ve	203	5	208	15.00‡	0.20	0.50±0.20
	- ve	133	12	145			
	Total	336	17	353			
2 Localities	+ ve	323	15	338	20.17‡	0.19	0.50±0.11
	- ve	163	32	195			
	Total	486	47	533			

‡ Significant, P<0.001, ‡‡C= Coefficient of Contingency. ‡‡‡$C_{AB} \pm SD$ = Coefficient of Interspecific Association ± Standard Deviation

When the relative abundance of the two species was considered (Table 2), the values of Sorensen's coefficients or the Index of Association (*I*) indicated high association in El-Muqattam (0.88) and moderate association in Abu-Seir (0.47) or when the two localities were combined together (0.53).

Table 2. Sorensen's coefficient or Index of association between ***Cx. pipiens*** and ***Cx. perexiguus***

Locality	Number of the 2 species		Index of Association (*I*)
	Total (A+B)	Present to gether (J)	
El-Muqattam	1874	1757	0.88
Abu-Seir	12665	9331	0.47
2 Localities	14539	11088	0.53

The Index of Association showed monthly variations (Fig. 3) which were parallel to the fluctuations in monthly densities of the two species altogether. Moreover, regression analysis indicated that (*I*) values increased as densities of the two species (either of each species or compiled of the two species) increased (b= 0.01-0.02) in El-Muqattam (P>0.05), Abu-Seir and in the

two localities together (P<0.05).

Table 3: Regression analysis for the relation of larval densities of the two mosquito species and the Sorensen's coefficients of interspecific association (I)

	El- Muqattam			Abu- Seir			2 localities		
	Cx. pipiens	*Cx. perexiguus*	Two species	*Cx. pipiens*	*Cx. perexiguus*	Two species	*Cx. pipiens*	*Cx. perexiguus*	Two species
a	0.75	0.76	0.74	0.09	0.15	0.10	0.40	0.44	0.41
b	0.01	0.02	0.01	0.01‡	0.02‡	0.01‡	0.01‡	0.01‡	0.01‡
R^2	0.15	0.16	0.18	0.27	0.28	0.28	0.36	0.37	0.37

a = intercept, b = slope or regression coefficient, R^2= Coefficient of Determination,
‡ Significant, P<0.05, t-test

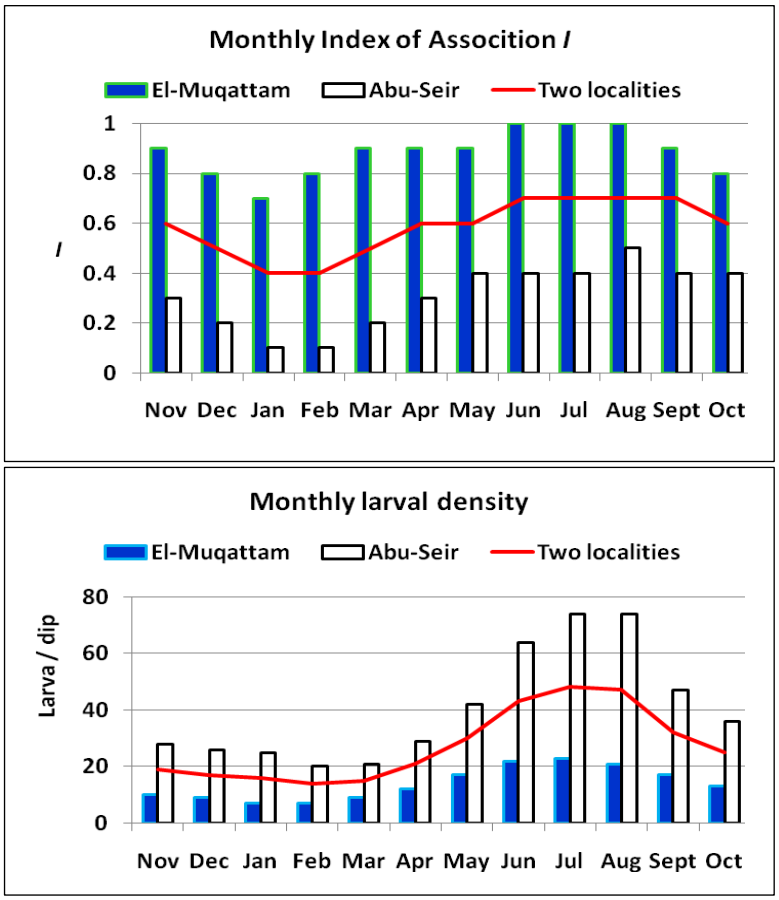

Fig. 3: Monthly estimates of the Index of association (above) in relation to the compiled larval densities of *Cx. pipiens* and *Cx. perexiguus* (below)

DISCUSSION

Hurlbert (1971) pointed out that in order to measure the degree of association between two species, the analysis of presence-absence data is preferable to that of relative numbers, whereas Southwood (1991) indicated that both methods should be employed as a positive association on presence-absence data and a weaker or negative one on abundance data would suggest (not prove) interspecific competition that require further analysis. Moreover,

Kenawy (1990) pointed out that as the index (*I*) depends on the number of larvae which can not exactly be sampled, this may suggest that assessment of association would be easier and more reliable if based on calculation of (*C*) and (C_{Ab}) rather than on (*I*).

Fager (1957) has demonstrated that no association will be seen on the presence-absence data if the two species occur in most of the samples and so are nearly found together. This was observed for *Cx. pipiens* and *Cx. antennatus* in the Nile Delta, Egypt by El-said *et al.* (1983) who indicated that in spite of their abundance and high frequency of the joint occurrence, the two species were found to have significantly (P<0.01) negative association (*ca.* -0.2 on presence-absence data and -0.5 on abundance data) which may indicate no association. However, Abdel-Hamid (2012) observed high degrees of associations among the common species, *Cx. pipiens, Cx. perexiguus* and *Cx. antennatus* ($C_{AB=}$ 0.76 - 0.87, I= 0.79 - 0.92) in the northern part of Egypt (Nile Delta and El-Ismailia Governorate). In the present study although *Cx. pipiens* and *Cx. perexiguus* were common and use the same habitats, they had a significantly slight/ moderate association (P<0.001) based on presence-absence data. The values of Sorensen's coefficients indicated moderate to high association (0.47-0.88) in the two localities. Such coefficient showed seasonal variations and directly related to densities of the two species in El-Muqattam (P>0.05), Abu-Seir (P<0.05) and in the two localities together (P<0.05). Similarly, the association parameters of *Cx. pipiens* and *Cx. antennatus* also showed seasonal variations but indirectly related to the fluctuation in larval densities of the two species (Kenawy, 1990). From the study, It can be concluded that such significantly positive association between *Cx. pipiens* and *Cx. perexiguus* indicates that the requirements of the two species are similar and that the larval densities of the two species influencing the degree of such association.

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ARABIC SUMMARY

تحليل ألأرتباط بين يرقات بعوض كيولكس ببيانز و كيولكس بريكسيجوس (ذات الجناحين: كيوليسيدى) في اثنين من البيئات الحضرية بالقاهرة، مصر

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أجريت المسوحات الحشرية ليرقات البعوض لمدة عام فى اثنين من المناطق الحضرية بالقاهرة (المقطم وأبو صير). تم قياس مدى ألأرتباط بين النوعين الشائعين: كيولكس ببيانز وكيولكس بريكسيجوس على اساس تواجد/عدم تواجد يرقاتها واعدادها النسبية (معامل سورنسن). وقد اظهرا هذين النوعين ارتباطآ طفيف/متوسط (اعتماداً على تواجد/عدم تواجد يرقاتها). اوضحت قيم معامل سورنسن درجة عالية من ألأرتباط في المقطم (0.88)، ومتوسطة في أبو صير (0.47) أو في المنطقتين مجتمعة (0.53). كما اظهر هذا المعامل تباين شهري يرتبط مباشرة بالكثافات المنفصلة/المجمعة لهذين النوعين. وقد دللت النتائج التي تم الحصول عليها إلى التشابه فى متطلبات التوالد لهذين النوعين من البعوض وان كثافة يرقاتها تؤثر على درجات ارتباطها.