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Algae and plant flora of the mosquito breeding habitats in two urbanized areas of Cairo, Egypt

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ABSTRACT

The present study was carried out in two urban areas in Cairo Governorate namely El-Muqattam and Abu-Seir. For each locality, the breeding habitats were monthly inspected (Nov. 2009 to Oct. 2010) for mosquito larvae. Along with larval collection, samples of algal mats/ scum and of terrestrial and aquatic plants surrounding and within the breeding habitats were collected. Thirteen algal taxa belonging to 4 divisions: Cyanophyta (3), Bacillariophyta (7), Chlorophhyta (2) and Xanthophyta (1) were identified in the two localities. Eighteen plant species of fifteen families were collected of which, sixteen species were terrestrial and only two were aquatic. Examining the dependence of the reported mosquito species (*Culex pipiens, Cx. perexiguus, Cx. pusillus*, *Ochlerotatus caspius*, *Culiseta longiareolata* and *Anopheles multicolor*) on the occurrence of certain algal/aquatic plant species revealed that all relations were insignificant (χ^2=0.00 -2.22, *d.f.*=1, *P*>0.05) except the dependence of *Cx. pipiens* on the occurrence of the unicellular green alga *Cosmarium sp.,* and filamentous green algae of *Oedogonium sp.* and *Spirogyra sp.* in Abu-Seir (χ^2=5.99, *d.f.* =1, *P*<0.05).

INTRODUCTION

It was reported (Sunish and Reuben, 2002; Greenway *et al.*, 2003; and Mutuku *et al.*, 2009) that the presence of floating plants and algae provide optimal breeding conditions for mosquito larvae by acting as food sources, shelter from predators, create stagnant conditions by decreasing water movement and offering newly emerged adults and gravid mosquitoes a shaded resting site. Algae as a group contains more essential nutrients, such as polyunsaturated fatty acids and sterols, necessary for mosquito development and adult emergence (Cole *et al.*, 1988).

Moreover, grasses and weeds along the banks of breeding sites provide shade and shelter for *Anopheles* and *Culex* larvae while the mangrove trees provide resting sites for the adults (Opoku *et al.*, 2007). However, it is common in nature for several species of *Aedes, Anopheles* and *Culex* mosquito larvae to die before completing their development because they are poisoned by algae that demonstrate larvicidal activity and produce toxins which alter mosquito development (Marten, 1987; Dhillon and Mulla, 1981 & 1982; Abdel-Hameed and Kiviranta, 1993 and Abdel-Hameed *et al.*, 1994).

Several authors (Savage *et al.*, 1990; Walton *et al.*, 1990; Rejmankova *et al.*, 1993; Fernandez-Salas *et al.*, 1994; Marten *et al.*, 1996; Gimnig *et al.*, 2001; Sunish and Reuben, 2002; Fillinger *et al.*, 2004 and Castro *et al.*, 2010) observed positive relation between mosquito larvae and the presence of vegetation and algae. From other side, kenea *et al.* (2011) in Ethiopia, found a negative association with algae content and a positive association with a low density of grass-vegetation with the densities of mosquito larvae. Matthys *et al.* (2006) in western Côte d'Ivoire, reported that water surfaces abundantly covered by floating vegetation result in reduced mosquito larval densities because of shadowing by the vegetation cover.

In Egypt, few studies (Gad *et al.*, 1984; Abd-El-Meguid, 1987; and Abdel-Hamid *et al.*, 2011), demonstrated the presence of mosquito larvae in breeding habitats with algae and emergent vegetations. El-Kassas (1997) studied the factors influencing mosquito distribution in Faiyum and collected 32 algal genera belonging to 3 main divisions namely Bacilllariophyta, Chlorophyta and Cyanophyta. Regression analysis revealed that densities of *Cx. perexiguus, Cx. pipiens, Cx. pusillus* and *Oc. caspius* had a non significant positive correlation with algal taxa and total algae. Rashed and El-Ayouty (1991) however, reported mortality of *Cx. pipiens* caused by three unicellular *spp.* of algae, *Chlorella vulgaris*, *Chlamydomonas reinhardtii* and coccoid blooming cyanophycean, *Microcystis aeruginosa* and Ahmad *et al.* (2001) reported that some algae can prevent mosquito oviposition.

This study was planned to examine the plant and algal flora of the mosquito breeding habitats as factors influencing the mosquito distribution in two urban localities of Cairo Governorate.

MATERIAL AND METHODS

The Study Area

The present study was carried out in two localities representing different levels of urban planning in Cairo Governorate (Fig. 1) namely El-Muqattam (30º 21´ 21"- 29º 58' 52" N, 31º 20´ 52"- 31º 16´ 1" E) which is located in southeast of Cairo on a hill, with an average altitude of 100 m above sea-level and Abu-Seir (30º 10´ 43"- 30 º 09´ 11 N, 31 º 23´ 56"- 31º 22´ 11" E) which is located in northeast of Cairo within El-Marg district.

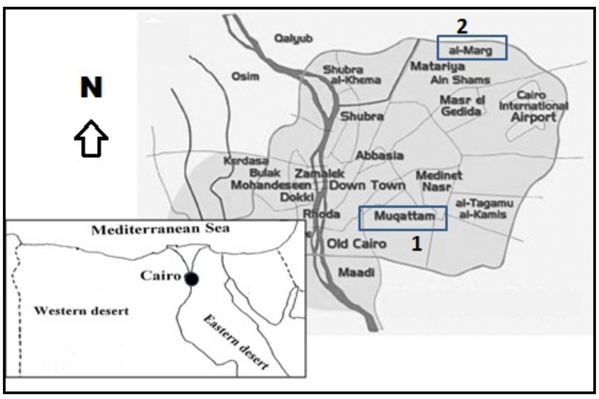

Fig. 1: Location of the two study localities; El-Muqattam (1) and Abu-Seir (2) within Cairo Governorate.

El-Muqattam (M) is considered as a planned area, but more than 40% of it is considered as unsafe because it lacks a piped sewage system. Abu-Seir (AS) is considered as unplanned unsafe area according to the National slum upgrading policy criteria (Ammar *et al.* 2012).

Collection of Mosquito Larvae

The breeding habitats in the two localities were monthly inspected for mosquito larvae from Nov. 2009 to Oct. 2010. Larvae were collected by dipping using a plastic dipper, 12.5 cm in diameter with a 90 cm wooden handle. Collected larvae were placed in labeled plastic bags and transported to the laboratory where 3rd and 4th instars were identified.

Collection and Identification of Algal and Plant Flora

For each breeding site, the algal mats and scum were removed using a sharp blade shovel or by hand. Samples were tipped into labeled small glass bottles, half filled with water from the breeding site and transported to the laboratory in a thermos box contained cold water. At the laboratory, algal samples were preserved in 4% formalin containing few drops of 0.1% copper sulphate solution. Each sample was divided into two parts, one for preparing and identifying diatoms while the other was used for identifying the other algal species. The diatoms were prepared and mounted according to Proschkina-laverenko *et al*. (1974) and Jouse *et al.* (1949). Identification of the different algal groups was performed by using a binocular microscope with an oil immersion lens for diatoms and 40X for the other algal groups. The algal taxa were identified according to Desikachary (1959), Prescott (1961) and Krammer and lange-Bertalot (1988).

Samples of aquatic and terrestrial plants within and surrounding the breeding habitats were collected and identified at situ according to Montasir and Hassib (1956), Täckholm (1974) and Boulos (1999).

Statistical Analysis

To examine the dependence of the reported mosquito larval specie on certain algal and aquatic plant species of the breeding habitat, the 2x2 contingency tables were constructed and chi-squared (χ^2) was calculated based on the frequency of mosquito species occurrence comparable to the occurrence of each algal/plant species in the different breeding habitats. The PAST (PAleontological STatistics version 2.08, Hammer *et al.* 2001) computerized software was used for statistical analysis.

RESULTS

Reported Mosquito Species

Six mosquito larval species were reported in the different breeding habitats of the two localities. These were: *Culex* (*Culex*) *pipiens* Linnaeus, *Cx.* (*Cux.*) *perexiguus* Theobald, *Cx.* (*Barraudius*) *pusillus* Macquart, *Ochlerotatus* (*Ochlerotatus*) *caspius* (Pallas), *Culiseta* (*Allotheobaldia*) *longiareolata* (Macquart) and *Anopheles* (*Cellia*) *multicolor Cambouliu*

Algae and Plant Flora of the Breeding Habitats

From the two localities, a total of 13 algal taxa belonging to 4 divisions: Cyanophyta (3), Bacillariophyta (7), Chlorohyta (2) and Xanthophyta (1) were identified (Table 1). Qualitatively, Cyanophyta was represented by three species of *Oscillatoria*. Five species of bacillariophytes were enumerated in most of the collected samples. Macroscopic filamentous green algae of *Oedogonium sp.*, *Mougeotia sp*. and *Spirogyra sp*. together with microscopic *Cosmarium granatum* constituted the green algal flora of the seepage water in AS; while the densely green algal mats of *Mougeotia sp.* was the only green algal taxon recorded in two habitat types of M namely spring and spring canal. *Tribonema affine*, the bloom forming species was also recorded in spring and spring canal (M) and had the yellow- green color appearance distributed on the surface of water.

A total o 18 plant species of 15 families were collected from the two localities. Of these, only two were aquatic within the breeding habitats (Table 1) and 16 were terrestrial around the breeding habitats (Table 2). Fifteen species of terrestrial plants were present in AS and only three species were present in M (all in the planned safe areas). Of the 16 collected species only two (*Phragmites australis* and *Tamarix aphylla*) were present in the two localities, one species (*Cynanchum acutum*) was present only in M; while the other 13 species were collected only in AS. The two species of aquatic plants (*Lemna gibba* and *Eichhornia crassipes*) were collected only from AS.

Table 1: Distribution of identified algal taxa, aquatic plants and mosquito larvae in different breeding habitats of the two localities.

			El-Muqattam				**Abu-Seir**				
			Spring	**Spring canal**	**Cesspit**	**Cesspool**	**Drainage Canal**	**Cesspit**	**Cesspool**	**Irrigation ditch**	**Seepage water**
Algal Taxa											
Division	**Species**										
Cyanophyta	*Oscillatoria geminata* Menengh. ex Gomont						●			●	●
	O. jasorvensis Vouk					●	●		●		
	O. okenii Agardh ex gomont.						●				
Bacillariophyta	*Nitzschia palea var. Debilis* (Kütz.) Grun.				●	●	●		●		
	N. obtusa var. kurzii (Rabenhorst) Grun.		●	●							
	Synedra ulna (Nitzsch) Ehr.				●			●			
	Fragilaria construens (Ehr.) Grun		●	●							
	Achnanthes minutissima kütz		●	●							
	Cosmarium granatum Breb. ex Ralfs										●
	Oedogonium sp.										●
Chlorohyta	*Spirogyra sp.*										●
	Mougeotia sp.		●	●							
Xanthophyta	*Tribonema affine* (kütz.) G.S. West		●	●							
Aquatic plant Taxa											
Family	**Species**	**Common name**									
Lemnaceae	*Lemna gibba*	Gibbous Duckweed					●				●
Pontederiaceae	*Eichhornia crassipes*	water hyacinth					●				
Mosquito species											
Cx. pipiens			●		●	●	●	●	●	●	
Cx. perexiguus			●		●	●	●		●	●	
Cx. pusillus							●	●	●		
Oc. caspius			●				●			●	
Cs. longiareolata			●		●						
An. multicolor			●								

Table 2: Distribution of identified terrestrial plants around mosquito breeding habitats of the two localities.

Plant Taxa			**Habitat type**								
			El-Muqattam				**Abu-Seir**				
Family	**Species**	**Common name**	**Spring**	**Spring canal**	**Cesspit**	**Cesspool**	**Drainage Canal**	**cesspit**	**Cesspool**	**Irrigation ditch**	**Seepage water**
Amaranthaceae	*Chenopodium album*	Lamb's quarters					●				
	Chenopodium murale	Nettleleaf goosefoot					●				
Asclepiadaceae	*Cynanchum acutum*	Montpellier scamony plant	●	●							
Arecaceae	*Phoenix dactylifera*	True date palm					●		●		
Casuarinaceae	*Casuarina equisetifolia*	Beach Sheoak					●				
Compositae	*Conyza dioscoridis*	Ploughmans spikenard									●
Convolvulaceae	*Convolvulus lineatus*	Pygmy Bindweed					●				
Fabaceae	*Alhagi Gagnebin*	alhagi					●				
Leguminosae	*Caesalpinia regia*	flame tree					●				
Moraceae	*Ficus nitida*	Laurel Fig					●				
Myrtaceae	*Eucalyptus camaldulensis*	River red gum					●				
Poaceae	*Phragmites australis*	Common reed	●	●			●				●
	Zea mays	corn					●			●	
Salicaceae	*Salix mucronata*	Cape Silver Willow					●				●
Tamaricaceae	*Tamarix nilotica*	Nile tamarisk					●				
	Tamrix aphylla	Athel pine	●	●			●				

Dependence of Mosquito Larval Species on the Occurrence of Algae and Aquatic Plants

Examining the dependence of the reported mosquito species on the occurrence of certain algal/aquatic plant species of the breeding habitat (Table 3) revealed that all relations in the two localities were insignificant (χ^2=0.00 -2.22, *d.f.* = 1, *P*>0.05) except the dependence of *Cx. pipiens* on the occurrence of the following green alga *Cosmarium sp.* and the green filaments of *Oedogonium sp.* and *Spirogyra sp.* in AS (χ^2=5.99, *d. f.* = 1, *P*<0.05)

Table 3: Chi-squared analysis for the relation of the occurrence of mosquito larvae, algae and aquatic plants in all breeding habitats of the two localities.

	El-Muqattam					**Abu-Seir**			
	Cx. pipiens	***Cx. perexiguus***	***Oc. caspius***	***Cs. longiareolata***	***An. multicolor***	***Cx. pipiens***	***Cx. perexiguus***	***Oc. Caspius***	***Cx. pusillus***
	χ^2(*P<0.05)								
Algal Taxa									
Oscillatoria jasorvensis	0.44	0.44	0.44	1.33	0.44	0.86	2.22	0.14	2.22
O. geminata						0.86	0.14	2,22	2.22
O. okenii						0.31	2.22	1.88	2.22
Nitzschia palea var. debilis	0.44	0.44	0.44	0.00	0.44	0.86	2.22	0.14	2.22
N. obtusa var. kurzii	0.44	0.44	0.44	0.00	0.44				
Synedra ulna	0.44	0.44	0.44	1.33	0.44	0.31	2.22	0.31	2.22
Fragillaria construens	0.44	0.44	0.44	1.33	0.44				
Achnanthes minutissima	0.44	0.44	0.44	0.00	0.44				
Mougeotia sp.	0.44	0.44	0.44	0.00	0.44				
Tribonema affine	0.44	0.44	0.44	0.00	0.44				
Cosmarium granatum						5.99*	2.22	0.83	1.88
Oedogonium sp						5.99*	2.22	0.83	1.88
Spirogyra sp						5.99*	2.22	0.83	1.88
Aquatic plant Taxa									
Lemna gibba						1.88	0.14	0.14	0.14
Eichhornia crassipes						0.31	0.83	0.83	1.88

DISCUSSION

In the present study, 13 algal species of 4 divisions were collected from the different breeding habitats in the two localities. Different distributions of the algae were observed depending on types of the breeding habitat and locality. Of the identified algae, four species (*Oscillatoria jasorvensis, O. okenii, Nitzschia palea* and *Synedra ulna*) were collected from unsafe areas whether planned (M) or unplanned (AS). Five species (*Nitzschiaobtusa var. kurzii, Fragillaria sp., Achnanthes sp., Mougeotia sp.* and *Tribonema sp.*) were collected only from planned safe areas of M. Five species (*Oscillatoria geminate, O. okeni, Cosmarium sp., Oedogonium sp.* and *Spirogyra sp.*) were collected only from AS (unplanned unsafe). El-Kassas (1997) collected 32 algal species belonging to 3 main divisions from breeding water in Faiyum. Abdel-Hamid *et al.* (2011) in El Ismailia Governorate reported that mosquito larvae have a variety of breeding habitats with green and yellow-green algae. The presence of algae especially filamentous algae in the breeding water is observed to have nutritive value necessary for mosquito development and adult emergence and form mats that provide shelter which provide protection to the mosquito immatures especially against predators and water current (Cole *et al.*, 1988 and Sunish and Reuben 2002). However, It was demonstrated that some algae have larvicidal activity against several species of *Aedes*, *Anopheles* and *Culex* (Dhillon and Mulla, 1981 & 1982 and Abdel-Hameed and Kiviranta, 1993) causing mortality or delay in the development of the larvae (Rashed and El-Ayouty, 1991) and it is common in nature for mosquito larvae to die before completing their development because they are poisoned by algae that produce toxins or they starve to death while feeding on algae that are indigestible (Marten, 1987).

Analysis of data revealed the dependence of *Cx. pipiens* on the occurrence of the green unicellular alga *Cosmarium granatum* (F. *Desmidiaceae*), and the filamentous green algae of *Oedogonium sp.* (F. *Oedogoniaceae*) and *Spirogyra sp.* (F. *Zygnemataceae*) in AS (P<0.05). Similarly, Savage *et al.* (1990) reported a phytoecological relationship between *An. pseudopunctipennis* larvae and the green-filamentous algae.

It was reported (Walton *et al.*, 1990) that vegetation type and proportion of coverage are implicated as being better predictors of larval abundance than the physico-chemical factors. In a concurrent study (Kenawy *et al.*, 1913), the physico-chemical characteristics of the breeding habitats were examined relative to the distribution and abundance of mosquito larval species in the same two localities. In the present study, 18 plant species of 15 families were collected from the two localities. Of these, 16 were found around the breeding habitats and only two were aquatic plants within the breeding habitats. Such plants around the breeding habitats provide shelter for larvae and resting places for adults. Opoku *et al.* (2007) observed that grasses and weeds along the bank of Kpeshie lagoon in Ghana provide shade and shelter for *An. melas* and *Cx. thallassius* larvae, while the mangrove trees provide resting sites for the adults. In Egypt, Abd-El-Maguid (1987) and Abdel-Hamid *et al.* (2011) in El Ismailia reported that mosquito larvae have a variety of breeding habitats with submerged and emergent vegetations. The more common of terrestrial plants in AS (13 species) than in M (3 species) may be due to the agricultural nature of AS.

The Two identified species of aquatic plants (The Gibbous Duckweed, *Lemna gibba* and the water hyacinth, *Eichhornia crassipes*) were from AS. This may explain the more common of mosquitoes (*ca*. 67%) in habitats with vegetation in AS (P<0.05) as compared to M (*ca.* 36%) (Ammar *et al.* 2013). These floating plants are reported to provide optimal breeding conditions by acting as food sources, shelter from predators and create stagnant conditions by decreasing water movement (Walton *et al.*, 1990 and

Greenway *et al.* 2003) and offering newly emerged adult and gravid mosquitoes a shaded resting site (Mutuku *et al*. 2009).

In the present study, analysis revealed insignificant relations (χ^2=0.14-1.88, *d.f.* = 1, *P*>0.05) of occurrence of the different mosquito species with the occurrence of the two identified aquatic plants. In contrast, a positive association is found between mosquito larvae and the presence of aquatic vegetation and algae (Fernandez-Salas *et al.* 1994 in Mexico, Gimnig *et al.* 2001 in western Kenya, Castro *et al.* 2010 in Tanzania and Kenea *et. al.* 2011 in Ethiopia). However, Matthys *et al*. (2006) in western Côte d'Ivoire reported that water surfaces abundantly covered by floating vegetation result in reduced mosquito larval densities because of shadowing by the vegetation cover. Moreover, Kenawy, *et al.* (1996) indicated that aquatic plants positively affect the occurrence of *Cx. antennatus, Cx. perexiguus* and *An. pharoensis* while their absence affect the breeding of *Cx. pipiens* and *Cs. longiareolata*.

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RABIC SUMMARY

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أجريت هذه الدراسة في اثنين من المناطق الحضرية في محافظة القاهرة وهي المقطم وأبو صير . تم استكشاف اماكن توالد يرقات البعوض بكلا المنطقتين شهريا (نوفمبر 2009 إلى أكتوبر 2010). بالأضافة الى ذلك تم جمع عينات من الطحالب، النباتات المائية والنباتات المحيطة باماكن التوالد. تم تشخيص ثلاثة عشر نوعاً من الطحالب تنتمي إلى 4 أقسام: Cyanophyta (3)، Bacillariophyta (7)، Chlorophhyta (2) و Xanthophyta (1) من المنطقتين. كما تم جمع ثمانية عشر نوعا من النباتات تمثل خمسة عشرعائلة، منها ستة عشر من الأنواع االأرضية و اثنين من ألأنواع المائية . بدراسة ارتباط تواجد أنواع البعوض المستكشفة (كيولكس ببيانز ، كيولكس بريكسيجوس ، كيولكس بوسيلوس، أوكليروتاتس كاسبيس ، كوليسيتا لونجياريولاتا و انوفيلس ملتيكولور) ببعض ألأنواع من الطحالب / النباتات المائية وجد أن جميع العلاقات كانت ضئيلة (P>0.05) باستثناء اعتماد كيولكس ببيانز في أبو صير (P<0.05) على تواجد الطحلب الأخضر وحيد الخلية من جنس *Cosmarium* و الطحالب الخضراء الخيطية من جنس *Oedogonium* و *Spirogyra*.