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Research Article

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ABSTRACT

The knowledge of the natural characteristics of the mosquito breeding habitats is important for implementing effective larval control program. For this, the association of six mosquito species (*Culex pipiens*, *Cx. perexiguus*, *Cx. pusillus*, *Ochlerotatus caspius*, *Anopheles multicolor* and *Culiseta longiareolata*) with the physical characteristics of their breeding habitats was examined in El-Muqattam and Abu-Seir; of the urban areas in Cairo Governorate. Based on the highest frequency of occurrence ($P<0.05$) of mosquito larvae comparable to each habitat character, the determinant factors for breeding of such species were concluded. Such factors were in El- Muqattam: small sites (<10m perimeter), stagnant and clear water, absence of predators (*Gambusia affinis*) and absence of aquatic vegetations. In Abu-Seir: large sites (>10m perimeter), mud bottoms, presence of aquatic vegetations and absence of predators. The study concluded that the environmental control measures based on modifying habitat characteristics can be effective in controlling targeted mosquito species specially those vectors of diseases.

Keywords: Mosquito larvae, characteristics of breeding habitats, urban areas, Cairo, Egypt.

INTRODUCTION

Twenty nine mosquito species belong to five genera (*Culex*, *Anopheles*, *Culiseta, Ochlerotatus* and *Uranotaenia*) are indigenous in Egypt, of which seven species*: Culex* (*Culex*) *pipiens* Linnaeus*, Cx.* (*Cx.*) *perexiguus* Theobald*, Cx. (Cx.) antennatus* Becker*, Cx.* (*Barraudius*) *pusillus* Macquart, *Ochlerotatus* (*Ochlerotatus*) *caspius* (Pallas), *Culiseta* (*Allotheobaldia*) *longiareolata* (Macquart) and *Uranotaenia* (*Pseudoficalbia) unguiculata* Edwards) are present in the urban areas of Cairo Governorate (Tawfick, 1990; Morsy et al., 2003).

Mosquitoes in Egypt play an important role in disease transmission for example (1) Culicine mosquitoes mainly *Cx. pipiens* and *Cx. perexiguus* are vectors of filariasis (Southgate, 1979), Rift valley fever virus (Meegan et al*.,* 1980), West Nile virus (Hurlbut et al*.,* 1956) and several other viruses (Darwish and Hoogstraal, 1981), (2) Of the anopheline species, *Anopheles pharoensis* and *An. sergentii* are the proven malaria vectors and *An. multicolor* is suspected as a vector (Kenawy, 1988).

The knowledge of ecological features of the mosquito breeding sites is a potential key element for implementing efficient and effective larval control measures (Killeen et al*.,* 2002; Sattler et al., 2005) and is to glean information on factors that may determine oviposition, survival, and the spatial and temporal distribution of important disease vector species (Piyaratne et al., 2005). 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). Several studies examined the habitat characteristics of mosquito larvae specially the anopheline vectors of malaria (*e.g.* Piyaratne et al*.,* 2005 in Sri Lanka; Fillinger et al*.,* 2009 in the Gambia).

In Egypt, few studies (Kenawy and El Said, 1990; Kenawy et al*.,* 1996; Abdel-Hamid et al*.,* 2011) examined the physical characteristics of the mosquito breeding habitats however ; none have such investigations in urban

areas. For this, the present study was planned to examine such characteristics in two urban localities in Cairo Governorate. This will be of help in planning of control programs.

MATERIALS AND METHODS

Study Localities

The study was carried out in two localities representing different levels of urban planning in Cairo Governorate (Figure 1) namely El-Muqattam (30° 21´ 21"- 29° 58' 52" N latitudes and 31° 20´ 52"- 31° 16´ 1" E longitudes) 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 and 31 º 23´ 56"- 31º 22´ 11" E) which is located in northeast of Cairo within El-Marg district. 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).

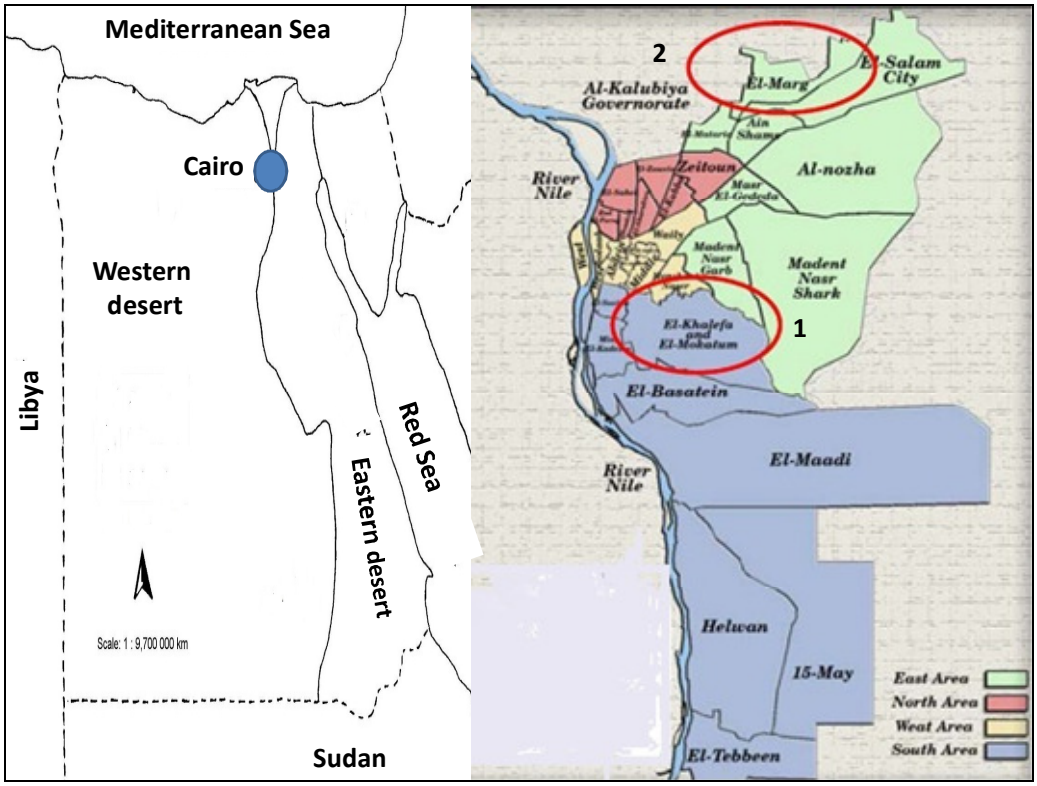

Fig. 1: The two study localities: El-Muqattam (1) and Abu-Seir (2) within Cairo Governorate

Larval Survey

Five types of the potential breeding habitats prevailing in the two localities (springs, cesspits, cesspools, irrigation ditches and drainage canals) were monthly inspected (Nov. 2009 to Oct. 2010) for mosquito larvae by dipping (WHO, 1975) 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 for identification.

Characteristics of the Breeding Habitats

Along with larval collections, the natural characteristics of the breeding habitats were recorded. Such characteristics included: the distance to the nearest house, perimeter, water depth, water movement, exposure to sunlight, type of the bottom, and presence or absence of solid wastes, vegetations and predators mainly the fish (*Gambusia affinis*).

Statistical Analysis

The occurrence frequencies of each reported mosquito species comparable to each characteristic of the breeding habitats were calculated and analyzed. The 2x2 and 2x3 contingency tables were constructed and χ^2 were calculated to examine the dependence of species occurrence on certain characteristics. The significant level was restricted to 5%. The SSP (Smiths Statistical Package) computerized software (Smith, 2004) was used for statistical analysis.

RESULTS AND DISCUSSION

Species Composition

Six mosquito larval species were reported of which *Cx. pipiens, Cx. perexiguus* and *Oc. caspius* were reported in the two localities, in addition to *An.* (*Cellia*) *multicolor Cambouliu* and *Cs. longiareolata* in El-Muqattam and *Cx. pusillus* in Abu-Seir. Moreover, *Cx. (Cx.) antennatus* Becker and *Ur. unguiculata* are present in the urban areas of Cairo Governorate (Tawfick, 1990; Morsy et al., 2003).

Types of Breeding Habitats

The different breeding habitats used by the reported mosquito larvae in the two localities are in table 1. The two common species, *Cx. pipiens* and *Cx. perexiguus* were found breeding in all habitats. In urban areas (Tawfick, 1990), mosquito breeding sites are usually associated with seepage water resulting from construction activities and from high underground water while in semi-urban areas, drainage canals and cesspools are the potential breeding sites. In the other areas of Egypt, several types of mosquito breeding habitats are reported (Harbach et al., 1988; Kenawy et al., 1996; Abdel-Hamid et al., 2011) including those encountered in the present study. Of the reported habitats, cesspits (El-Muqattam) and drainage canals (Abu-Seir) were the most common types (35.7 and 48.5% for the two habitats, respectively).

Table 1: Distribution of mosquito larvae in the breeding habitats in El-Muqattam (M) and Abu-Seir (A).

Species	Locality	Spring	Cesspit	Cesspool	Irrigation ditch	Drainage canal
Cx. pipiens	M	■	■	■		
	A		■	■	■	■
Cx. perexiguus	M	■	■	■		
	A			■	■	■
Cx. pusillus	A		■	■		■
Oc. caspius	M	■				
	A				■	■
An. multicolor	M	■				
Cs. longiareolata	M	■	■			

Breeding habitats were more common in unsafe areas whether planned (El-Muqattam, 9/14: 64.3%) or unplanned (Abu-Seir, 33/33: 100%) than in safe areas (El-Muqattam, 5/14: 35.7%).

Characteristics of the Breeding Habitats

Certain characteristics of the breeding habitats were significantly more common than the others in the two localities (Table 2). These were: a distance of <10m from houses, stagnant water and absence of the predators. In addition habitats that were small, deep, shaded, with sand bottoms, and devoid of solid wastes and aquatic vegetations were common in El-Muqattam while in Abu-Seir, habitats that were large, exposed to sun, with mud bottoms, with shallow water (P>0.05), devoid of solid wastes (P>0.05) and had aquatic vegetations were common.

Table 2: Relative abundance (%) of the breeding habitat characteristics in El Muqattam (n=14) and Abu-Seir (n= 33) (* *P*<0.05; Chi-squared test).

Habitat characteristics		El-Muqattam	Abu-Seir
Distance from houses (m)	<10	50.0*	63.6*
	>10	14.3	36.4
	>100	35.7	---
Perimeter (m)	<10, Small	64.3*	30.3
	>10, Large	35.7	69.7*
Water depth (m)	<0.5, Shallow	42.9	54.6
	>0.5, Deep	57.1*	45.4
Water movement	Stagnant	85.7*	87.9*
	Flowing	14.3	12.1
Sun light	Shaded	57.1*	39.4
	Sunny	42.9	60.6*
Bottom	Sand	64.3*	---
	mud	---	93.9*
	Concrete	35.7	6.1
Solid wastes	Present	0	45.4
	Absent	100*	54.6
Aquatic vegetations	Present	35.7	66. 7*
	Absent	64.3*	33.3
Predators	Present	14.3	0
	Absent	85.7*	100*

The occurrence frequencies of each of the reported mosquito species comparable to each characteristic of the different breeding habitats in the two localities are in table 3.

Table 3: Occurrence percentages of mosquito larvae in relation to the characteristics of the breeding habitats in the two localities (* *P*<0.05, Chi-squared test).

Attributes		El-Muqattam						Abu-Seir.				
		Cx. pipiens (n=144)	*Cx. perexiguus* (n=144)	*Oc. caspius* (n = 36)	*An. multicolor* (n = 36)	*Cs. longiareolata* (n = 60)	All Species (n=144)	*Cx. pipiens* (n = 360)	*Cx. perexiguus* (n = 240)	*Cx. pusillus* (n = 180)	*Oc. caspius* (n = 96)	All species (n=360)
Distance from houses (m)	<10	58*	58*	0	0	0	58*	60*	50*	80*	0	60*
	>10	1 7	1 7	0	0	0	1 7	40	50	20	100*	40
	>100	25	25	100*	100*	100*	25	0	0	0	0	0
Perimeter (m)	<10, Small	75*	75*	0	0	0	75*	30	5	27	0	30
	>10, Large	25	25	100*	100*	100*	25	70*	95*	73*	100*	70*
Water depth (m)	<0.5, Shallow	50	50	0	0	40	50	53	70*	80*	37	53
	>0.5, Deep	50	50	100*	100*	60*	50	47	30	20	63*	47
Water movement	Stagnant	100*	100*	100*	100*	100*	100*	87*	80*	80*	63*	87*
	Flowing	0	0	0	0	0	0	13	20	20	37	13
Sun light	Shaded	50	50	100*	100*	80*	50	43	35	53	25	43
	Sunny	50	50	0	0	20	50	57*	65*	47	75*	57*
Bottom	Sand	58*	58*	100*	100*	60*	58*	--	--	--	--	--
	mud	--	--	--	--	--	--	93*	100*	93*	100*	93*
	Concrete	42	42	0	0	40	42	7	0	7	0	7
Solid wastes	Present	0	0	0	70*	0	0	43	65*	67*	37	43
	Absent	100*	100*	100*	100*	100*	100*	57*	35	33	63*	57*

Predators	Present	0	0	0	0	0	0	0	0	0	0	0
	Absent	100*	100*	100*	100*	100*	100*	100*	100*	100*	100*	100*
Aquatic vegetations	Present	25	25	100*	100*	60*	25	70*	95*	73*	100*	75*
	Absent	75*	75*	0	0	40	75*	30	5	27	0	25
Planned	Safe	25	25	100*	100*	60*	25	--	--	--	--	--
	Unsafe	75*	75*	0	0	40	75*	--	--	--	--	--
Unplanned	Unsafe	--	--	--	--	--	--	100	100	100	100	100

In El Muqattam, *Oc. caspius, An. multicolor* and *Cs. longiareolata* breed only (*P*<0.05*)* in sites far away from houses *(*>100m) while *Cx. pipiens* and *Cx. perexiguus* (*P*>0.05) preferred those near houses (<10m). In Abu Seir, all species preferred sites that were near houses (<10m) except *Oc. caspius* (*P*<0.05) which breed only in sites that were a little bit far of the houses (>10 m) and *Cx. perexiguus* was indifferently breeder (*P*>0.05) in sites whatever their distance from houses. This indicates that the occurrence/abundance of the three *Culex* species had negative associations with distance to houses suggesting that these species prefer laying eggs in habitats near houses while *An. multicolor* had a positive association in agreement with the findings of Kenea et al. (2011) for *Anopheles squamosus* larvae in Ethiopia.

Except for *Cx. pipiens* and *Cx. perexiguus* (*P*<0.05) in El-Muqattam, the other species in the two localities preferred (*P*<0.05) or only breed in larger habitats (>10m perimeter) in agreement with Margalit et al. (1988) observation in Israel, which indicates that *Cx. theileri* prefers large habitats while Salit et al. (1996) in Kuwait State, observed that *Cx. pipiens* breeds in a wide range of breeding habitats with various widths (0.5-100m).

In El-Muqattam, *Cx. pipiens* and *Cx. perexiguus* indifferentially breed (*P*>0.05) in shallow (<0.5m) and deep water while the other species preferred (*P*<0.05) deep water. In Abu-Seir, *Cx. pipiens* (*P*>0.05), *Cx. perexiguus* (*P*<0.05) and *Cx. pusillus* (*P*<0.05) preferred shallow water while *Oc. caspius* (*P*<0.05) preferred deep water. In Egypt, Kenawy et al. (1996) in El-Sharkiya Governorate observed that habitats with shallow water (<1m) are preferable for breeding of *Cx. antennatus* (*P*<0.05)*, Cx. perexiguus* (*P*<0.01) and *An. pharoensis* (*P*<0.05). The preference of several mosquito species for shallow water was also observed in the Canal Zone, Egypt for 9 culicine species (Kenawy and El Said, 1990) and in other countries for *Anopheles* mosquitoes (Gimnig et al*.,* 2001) and for *Cx. pipiens* (Salit et al*.,* 1996).

All species in the two localities preferred stagnant water (*P*<0.05) in agreement with Abdel-Hamid *et al* (2011) observation in El-Ismailia. Similarly, In El-Sharkiya Governorate Kenawy *et al* (1996) observed significant preference (*P*<0.05) for breeding in stagnant water for *Cx. pipiens, Cx. antennatus* and *Cs. longiareolata* while the other species (*Cx. perexiguus, Cx. pusillus, Ur. uniguiculata* and *An. pharoensis*) insignificantly breed (*P>0.05*) either only or more frequently in stagnant water.

Fritsch (1997) reported that the effect of sunlight or shade varies depending on the mosquito species. The favorable effect of sunlight on mosquito larval population is to the requirement of algae (favorable larval food) to sunlight. In this study, shade seems to be a determining factor (*P*<0.05) in the occurrence of *Oc. caspius, An. multicolor* and *Cs. longiareolata* while *Cx. pipiens* and *Cx. perexiguus* were indifferentially breeding *(P*>0.05*)* in shaded and sunny sites in El-Muqattam. In Abu-Seir, all species significantly (*P*<0.05) preferred sunny sites except *Cx. pusillus (P*>0.05*)*. Horsfall (1955) pointed out that light is not essential for development of *Cx. molestus*, *Cx. fatigans (=quinquefasciatus)* and *Cx. pipiens.* In El-Ismailia Governorate, mosquito larvae are found in semi-shaded or partially shaded habitats (Abdel-Hamid et al., 2011). In El-Sharkiya Governorate (Kenawy et al., 1996), larvae of *Cx. pipiens, Cx. pusillus* and *Cs. longiareolata* prefer shaded habitats (*P*<0.05). In Kuwait State (Salit et al., 1996), *Cx. pipiens* breeds in shaded, semi-shaded and sunlight exposed areas.

Results indicated that all species in El-Muqattam preferred sites with sandy bottoms (*P*<0.05) than those with concrete bottoms while in Abu-Seir, they preferred (*P*<0.05) those with mud bottoms. Abdel-Hamid et al. (2011) had similar observation that mosquito larvae are found in a variety of breeding habitats with mud bottoms.

Turbidity of the breeding water may partially due to the presence of solid wastes. In this study, all reported species in El-Muqattam preferred breeding in water devoid of solid wastes (*P*<0.05). In Abu Seir, both *Cx. pipiens* and *Oc. caspius* significantly (*P*<0.05) prefer breeding in water without solid wastes while *Cx. perexiguus* and *Cx. pusillus* prefer breeding (*P*<0.05) in water with solid wastes. Kenawy et al. (1996) observed that water turbidity (due to suspended matters) significantly affect breeding of *Cx. pipiens* and *Cx. perexiguus* (*P*<0.05) while clear water is preferable for breeding of *Cx. antennatus* and *Cs. longiareolata.* Salit et al. (1996) observed that *Cx. pipiens* larvae breed in places with or without visible turbidity. Sattler et al. (2005) indicated that in turbid breeding sites, culicine larvae are much more likely to be present, whereas *Anopheles* larvae are much more likely to be absent.

It was reported that predation influences the population dynamics of mosquito larvae and may be the most important single factor determining population size (Laird and Miles, 1985; Reisen et al., 1989), is considered as one of the most important factors causing the mortality of mosquito larvae in natural habitats (Carlson et al ., 2004 ;

Mwangangi et al., 2006) and could be an effective management tool for mosquito control (Blaustein and Chase, 2007). Results indicated that all reported species in the two localities were associated (P<0.05) with the absence of the predator, *Gambusia* fish. Several studies (*e.g.* Tabibzadeh et al., 1970; Victor et al., 1994) have shown the efficiency of fish in controlling both culicine and anopheline mosquito larvae under field conditions. Mosquito control using fish focuses on a limited number of species, primarily *Gambusia affinnis* and *Poecilia reticulata* (Walton, 2007).

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 (Greenway et al., 2003) and offering newly emerged adults and gravid mosquitoes a shaded resting site (Mutuku et al., 2009). Except for *Cx. pipiens* and *Cx. perexiguus* (P<0.05) in El-Muqattam, the other species in the two localities preferred presence of vegetation (P<0.05). In Egypt, the association between mosquito larvae and habitat vegetations was observed by Abdel-Hamid et al. (2011). 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*. Similarly, Fernandez-Salas et al. (1994) in Mexico, Gimnig et al. (2001) and Fillinger et al. (2004) in western Kenya, Castro et al. (2010) in Tanzania and Kenea et al. (2011) in Ethiopia found a positive association between mosquito larvae and the presence of vegetation and algae. 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.

In El-Muqattam, *Cx. pipiens* and *Cx. perexiguus* were more common in unsafe areas (P<0.05), *Oc. caspius* and *An. multicolor* breed only in safe areas (P<0.05) while *Cs. longiareolata* was significantly more common in safe area. No comparable studies are available.

In general, for all species together, the compiled percentage of occurrence comparable to each habitat characteristic was calculated (Tables 3). In El-Muqattam, mosquitoes were found breeding more frequently (P<0.05) in habitats near houses (<10) and having perimeters of <10m, sand bottoms, absence of solid wastes, and absence of aquatic vegetations while they only breed in habitats devoid of predators and having stagnant water. They indifferentially breed (P>0.05) in habitats whatever their water depths, whether exposed to sun light or shaded. Moreover they were common in unsafe planned area (P<0.05) than in safe one in agreement with the higher number of larvae present in planned unsafe areas than in safe ones (Ammar et al., 2012). In Abu-Seir, mosquitoes were found breeding more frequently (P<0.05) in habitats near houses (<10), exposed to sun, and having perimeters of >10m, stagnant water, mud bottoms, absence of solid wastes, and presence of aquatic vegetations while they only breed in habitats devoid of predators. They insignificantly more common (P>0.05) in habitats with water depth of <0.5m.

Based on significantly common or sole existence of mosquito larvae in breeding habitats, the following are the determinant factors for their breeding in the two areas: habitats that were near houses and having stagnant water, clear water and absence of predators.

CONCLUSION

Not only the type of breeding habitat but also its natural characteristics that determine the occurrence of a specific mosquito species in a certain habitat. So that environmental control measures based on modifying habitat characteristics can be effective in controlling targeted mosquito species specially those vectors of diseases.

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