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Mosquito breeding sources in Qalyubiya Governorate, Egypt.

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ABSTRACT

Water collections which may provide breeding habitats for mosquitoes in Qalyubiya Governorate were surveyed throughout the period from April 2009 to March 2011. Mosquito larvae were collected on monthly basis from 14 different breeding places in eight villages. A total of 1800 from 2821 sites (63.8%) were found positive for mosquitoes, including 312 canals, 271 pools, 191 unused wells, 166 rice fields, 142 irrigation channels, 130 ponds, 128 drainages, 115 catch basins, 85 irrigation basins, 82 ditches, 70 swamps, 66 temporary pools, 22 unused tires and 20 irrigation drainage tubes. Mosquito larvae were found in a variety of water collections including temporary, permanent, natural or man-made habitats. Permanent and semi-permanent water collections were the main sites for mosquito breeding. Nine mosquito species were identified in the study area namely, *Culex pipiens* 64.7%, *Culiseta longiareolata* 13.5%, *Cx. antennatus* 8.8%, *Aedes caspius* 6.3%, *Cx. vagans* 2.5%, *Cx. decens* 1.9%, *Cx. perexiguus* 0.9%, *Cx. univittatus* 0.8% and *Anopheles multicolor* 0.6%. Simple and Multiple regression models showed that temperature, Ammonia and Nitrate were the best predictors for mosquito larval density (P = 0.0397), (P = 0.0241) and (P = 0.0040), respectively. The year-round presence of immature mosquitoes indicates that climatic conditions of the area are not limiting to the development of most prevailing mosquito species. Catch basins, unused wells and drainages are playing the major role in mosquito problem in Qalyubiya Governorate.

Key words: Mosquitoes, Breeding, Ecology, Qalyubiya, Egypt.

INTRODUCTION

Mosquitoes exploit almost all types of lentic aquatic habitats for breeding. The breeding habitat is crucial for mosquito dynamics, because it is the location where many important life cycle processes take place: oviposition, larval development, emergence and probably resting, swarming, and mating (Overgaard *et al.,* 2002). The resources in terms of food, predators and competitors present in the habitat determine the population status of larval mosquitoes, both qualitatively and quantitatively (Carlson *et al.,* 2004).

Qalyubiya Governorate is situated in Southeastern of the Nile Delta and North of Cairo with area of 1124 km. It has various topographic strata including agricultural, semi-desert and desert areas. This has impact on diversity of mosquito breeding habitats. Mosquito larval habitat ecology is important in determining larval densities, relative importance of breeding habitats and species assemblage as well as designing mosquito control programs (Simsek, 2004). Many investigators surveyed mosquitoes and their breeding places in Egypt, among them are Barber and Rice 1937, Gad and Darwish 1957, Gad 1964, Wassif 1969, Margalit and Tahori 1973, Harbach 1985, Mohamed *et al.* (1994) Kenawy *et al.* (1996) Darwish (2000) Khater and Shalaby (2008) and Abdel-Hamid *et al.* (2011). In an earlier study in Qalyubiya Governorate, Hilmy *et al.* (1987) carried out a larval survey of culicid mosquito and revealed that wells and old sakia pits were found to play the major role in mosquito problem in Qalyubiya Governorate.

Results obtained from the present work may be essential in updating our knowledge about mosquito breeding habitats and designing of efficient strategies for mosquito control in this Governorate.

MATERIALS AND METHODS

Study area

The study was undertaken in Qalyubiya Governorate (30°28' N 31°11' E), 55 km North of Cairo, Egypt. Eight villages were selected to represent different topographic strata including agricultural, semi-desert and desert areas namely; Kafr Saad, Atreeb, Shiblanga, Batmda, Kafr Tahla, Tant El-Jazera, Kafr Tahoria and Akrasha (Fig.1). These villages are located in four districts namely; Benha, Tokh, Shibin El-Qanater and Abu Zabal. The majority of villages are typical urbanized Egyptian villages with high population density. In most cases latrine dumps are found at convenient sites in or outside houses as there were no sewage or garbage disposal systems. The villages are surrounded by agricultural lands and have many of water resources that are adjacent or descend through these villages. All potential breeding sites in the eight villages were recorded. Certain fixed breeding places representing all types of mosquito immature habitats were chosen for larval survey. Those fixed places were surveyed monthly from April 2009 to March 2011.

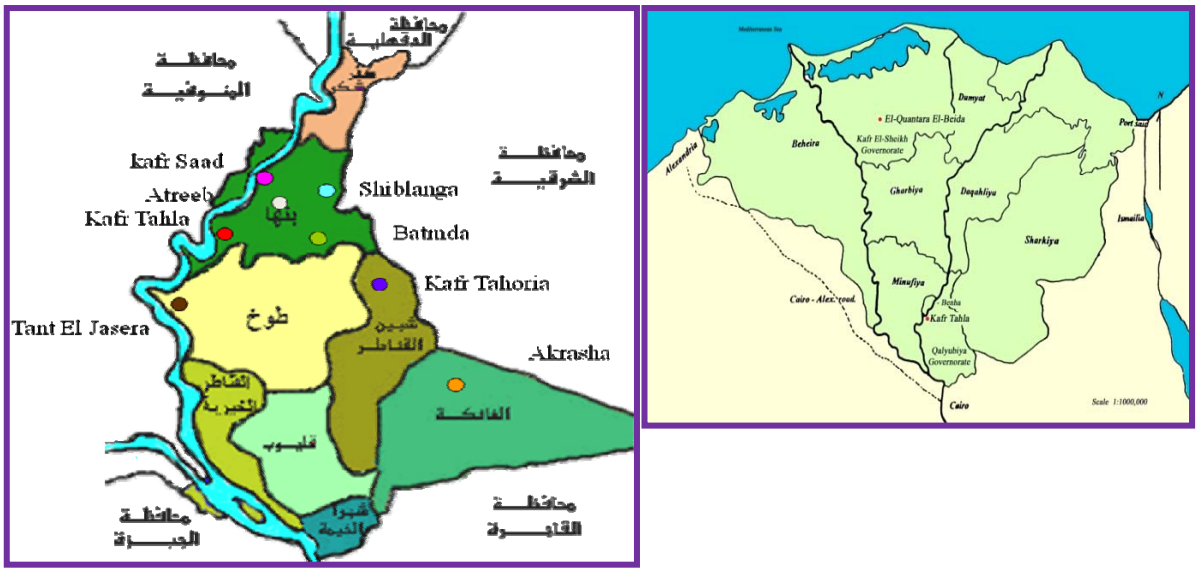

Fig.1: Map of Qalyubiya Governorate showing study sites.

Description of the breeding habitats and determination of physicochemical parameters

Breeding sites were categorized and classified where water movement was expressed as running, moderately and stagnant water. Vegetation was observed on each sampling, whereas duck-weed, water hyacinths, algae, emerging plants, standing plants and grasses were recorded. Physicochemical parameters of the studied breeding places were determined (depth, width, water temperature, vegetation, light, pH, Ammonia, Nitrate, salinity and dissolved oxygen). Chemical properties of the water of each breeding site were determined by sampling of water from different breeding types in polyethylene bottles 250 ml, tightly closed and labeled with breeding place type, number and date of collection. These bottles were surrounded with ice, till arrival to the National Water Research Center, El Qanater El khyria City (Qalyubiya Governorate) for analysis. Water salinity

and pH values were measured in the field by a portable TDS and pH meters. Ammonia and nitrate were estimated by Kjeldahl titration (Kjeldahl 1883) and Spectrophotometers, whereas dissolved Oxygen was determined according to the Winkler's method (Brower and Zar 1984).

Sampling of mosquito larvae

Mosquito larvae were sampled on monthly basis in eight villages from April 2009 to March 2011. Three dips were taken from each breeding site using stander dipper (450 ml with long handle). Large plastic pipettes and small white enamel pans were used for small and shallow water bodies. Larval densities were calculated as the average number of larvae per dip collected from each habitat. Collected larvae were transferred in separate plastic-bags and transported to the laboratory. Last third and fourth larval instars were identified to species level using keys of Harbach (1985, 1988), Ribeiro and Ramos (1999) and Azari-Hamidian and Harbach (2009).

Statistical analysis

Data was statistically analyzed using System Analysis Statistics (SAS) Program, version 6.12, 1998. Duncan's Multiple Range Test was performed to find out significant difference between breeding places. Pearson correlation and regression analysis were used to determine the relationships amongst the physicochemical parameters of breeding places and density of mosquitoes.

RESULTS

Mosquito larvae were found in a variety of water collections (14 types). A total of 1800 breeding places were found to be positive for mosquito larvae including 312 canals, 271 pools, 191 unused wells, 166 rice fields, 142 irrigation channels, 130 ponds, 128 drainages, 115 catch basins, 85 irrigation basins, 82 ditches, 70 swamps, 66 temporary pools, 22 unused tires and 20 irrigation drainage tubes (Table 1).

1. Canals are the most commonly used structure for conveyance of water for irrigation. This type is a permanent breeding site, water flow is moderate and chocking vegetation (water hyacinths) and other garbage were standing on some sides of canals with grasses (Fig. 2). In this type of breeding sites, a total of 26,099 mosquito larvae (13.3% of mosquitoes collected from all types of breeding sites) were collected.

Table 1: Mosquito larval habitats surveyed and the total number of larvae collected from eight villages of Qalyubiya Governorate throughout the whole period of study, from April 2009 to March 2011.

Type of breeding habitats	No of breeding sites inspected	No of +ve site for mosquitoes (%)	Total No of larvae collected (%)	Density (No of larvae/dip)
Canal	504	312 (61.9)	26099 (13.3)	77.7
Pool	360	271(75.3)	24813 (12.7)	103.4
Temporary pool	156	66 (42.3)	5329 (2.7)	37
Unused well	202	191 (94.6)	34791 (17.7)	145
Irrigation channel	196	142 (72.4)	20175 (10.3)	105.1
Drainage	145	128 (88.3)	19641 (10.0)	136.4
Catch basin	120	115 (95.8)	17998 (9.2)	187.5
Ditch	166	82 (49.4)	11228 (5.7)	58.5
Pond	158	130 (82.3)	17122 (8.7)	118.9
Irrigation basin	136	85 (62.5)	7843 (4.0)	81.7
Unused tire	102	22 (21.6)	406* (0.2)	8.5
Irrigation drainage tube	48	20 (41.7)	238 (0.1)	5
Rice field	400	166 (41.5)	2794 (1.4)	19.1
Swamp	128	70 (54.7)	7783 (3.9)	54.1
Total	2821	1800	196260 (100)	

* Larvae were surveyed with the pipette.

Data presented in Table 1 revealed that density (No. of larvae/dip) was 77.7 larvae were collected from canals, where the mean values of water temperature, pH, Ammonia, Nitrate, salinity and dissolved oxygen were 21°C, 8.6 pH, 0.38 mg/l, 25.6 mg/l, 1.18 ppt and 9.2 mg/l, respectively (Table 4). *Culex pipiens* was the most common species in this site, where the relative abundance was 93.5% (24413) followed by *Cx. antennatus* 3.4% (876), *Cx. vagans* 1.4% (359), *Cx. decens* 1.3% (329) and *Anopheles multicolor* 0.5% (122), (Table 2).

Table 2: Distribution and total number of mosquito larvae in different breeding habitats at Qalyubiya Governorate throughout the period from April 2009 to March 2011.

Type of breeding sites	**Total No of mosquito larvae collected▲**									
	Cx. pipiens	***Cx. antennatus***	***Cx. decens***	***Cx.vagans***	***Cx. univittatus***	***Cx. perexiguus***	***Cu. longiareolata***	***Ae. caspius***	***An. multicolor***	**Total**
Canal	24413	876	329	359	*	*	*	*	122	26099
Pool	14027	1552	800	783	*	*	2360	5000	291	24813
Temporary pool	3830	*	*	270	*	*	*	1229	*	5329
Unused well	22585	4160	1200	784	508	474	5080	*	*	34792
Irrigation channel	17345	1363	382	245	*	*	840	*	*	20175
Drainage	9316	1217	582	340	*	*	8186	*	*	19640
Catch basin	14467	*	*	*	*	*	3531	*	*	17998
Ditch	7385	1820	*	520	*	*	1502	*	*	11228
Pond	9470	1391	*	692	410	578	3155	1426	*	17122
Irrigation basin	3408	3966	*	*	200	269	*	*	*	7843
Unused tire	*	*	*	87	*	*	*	319	*	406
Irrigation drainage tubes	238	*	*	*	*	*	*	*	*	238
Rice field	181	607	431	185	500	470	*	*	420	2794
Swamp	450	231	*	600	*	*	1848	4305	350	7783
Total (**%**)	127115 (**64.7**)	17183 (**8.8**)	3724 (**1.9**)	4865 (**2.5**)	1618 (**0.8**)	1791 (**0.9**)	26502 (**13.5**)	12279 (**6.3**)	1183 (**0.6**)	196260

▲Total No of larvae; three dip/site throughout the whole period of study (i.e. 72 dips)
* No mosquitoes were recorded in this site.

2. Pools are widely distributed in the study areas. This site is depressed ground filled with water from flooding irrigated lands or damage of canal banks. Pools are semi-permanent breeding site with stagnant water (Fig. 2). In this type of breeding sites, a total of 24,813 mosquito larvae (12.7% of mosquitoes collected from all types of breeding sites) were collected. Data presented in Table 1 revealed that density was 103.4 larvae were collected from pools, where the mean values of water temperature, pH, Ammonia, Nitrate, salinity and dissolved oxygen were 23.8°C, 6.4 pH, 0.88 mg/l, 42.2 mg/l, 1.67 ppt and 6.8 mg/l, respectively (Table 4). *Culex pipiens* was the most common species in this site, where the relative abundance was 56.5% (14027) followed by *Aedes caspius* 20.2% (5000), *Culiseta longiareolata* 9.5% (2360), *Cx. antennatus* 6.3% (1552), *Cx. decens* 3.24% (800), *Cx. vagans* 3.15 (783) and *Anopheles multicolor* 1.2% (291), (Table 2).

3. Unused wells or Sakia pits were used for irrigation in past time and are usually neglected in the present time. Unused wells are permanent breeding sites and usually contain materials, such as mud, leaves, algae, debris and garbage (Fig. 2). In this type of breeding sites, a total of

34,791 larvae (17.7% of mosquitoes collected from all types of breeding sites) were collected. Data presented in Table 1 revealed that density was 145 larvae were collected from unused wells, where the mean values of water temperature, pH, Ammonia, Nitrate, salinity and dissolved oxygen were 24.5 °C, 7.5 pH, 1.32 mg/l, 66.4 mg/l, 1.74 ppt and 7.4 mg/l, respectively (Table 4). *Culex pipiens* was the most common species in this site, where the relative abundance was 64.9% (22585) followed by *Culiseta longiareolata* 14.6% (5080), *Cx. antennatus* 12.0% (4160), *Cx. decens* 3.4% (1200), *Cx. vagans* 2.3% (784), *Cx. univittatus* 1.5% (508) and *Cx. perexiguus* 1.4% (474), (Table 2).

4. Rice fields are seasonal breeding places, widely distributed in agricultural lands. Rice fields were surveyed for mosquito larvae during different phases of plant growth in summer season. The water was clear and stagnant (Fig. 2). In this type of breeding sites, a total of 2,794 larvae (1.4% of mosquitoes collected from all types of breeding sites) were collected. Data presented in Table 1 revealed that density was 19.1 larvae were collected from rice fields, where the mean values of water temperature, pH, Ammonia, Nitrate, salinity and dissolved oxygen were 23.5 °C, 8.2 pH, 0.57 mg/l, 30.1 mg/l, 1.62 ppt and 8.6 mg/l, respectively (Table 4). *Culex antennatus* was the most common species in this type of breeding sites, where the relative abundance was 21.7% (607) followed by *Cx. univittatus* 17.9% (500), *Cx. perexiguus* 16.8% (470), *Cx. decens* 15.4% (431), *Anopheles multicolor* 15.0% (420), *Cx. vagans* 6.6% (185) and *Cx. pipiens* 6.5% (181), (Table 2).

5. Irrigation channels are small channels used to irrigate the nearby fields. The water level changes according to the irrigation table or schedule time. These sites are chocking vegetation and debris of refused houses (Fig. 2). In this type of breeding sites, a total of 20,175 larvae (10.3% of mosquitoes collected from all types of breeding sites) were collected. Data presented in Table 1 revealed that density was 105.1 larvae were collected from irrigation channels, where the mean values of water temperature, pH, Ammonia, Nitrate, salinity and dissolved oxygen were 21.6 °C, 7.4 pH, 0.64 mg/l, 35.6 mg/l, 1.29 ppt and 8.4 mg/l, respectively (Table 4). *Culex pipiens* was the most common species in this type of breeding sites, where the relative abundance was 86% (17345) followed by *Cx. antennatus* 6.8% (1363), *Cs. longiareolata* 4.2% (840), *Cx. decens* 1.9% (382) and *Cx. vagans* 1.2% (245), (Table 2).

6. Ponds are similar to pools but they are bigger in size and deeper. This site is lowland filled with water from rains and waste water (Fig. 2). In this type of breeding sites, a total of 17,122 larvae (8.7% of mosquitoes collected from all types of breeding sites) were collected. Data presented in Table 1 revealed that density was 118.9 larvae were collected from ponds, where the mean values of water temperature, pH, Ammonia, Nitrate, salinity and dissolved oxygen were 24 °C, 6.8 pH, 0.91 mg/l, 44.2 mg/l, 1.73 ppt and 7.1 mg/l, respectively (Table 4). *Culex pipiens* was the most common species in this site, where the relative abundance was 55.3% (9470) followed by *Cs. longiareolata* 18.4% (3155), *Aedes caspius* 8.3% (1426), *Cx. antennatus* 8.1% (1391), *Cx. vagans* 4.0% (962), *Cx. perexiguus* 3.4% (578) and *Cx. univittatus* 2.4% (410), (Table 2).

7. Drainages are the largest breeding sites in the study areas. This type of breeding sites was usually neglected and was filled with materials like vegetation; water hyacinths, duck-weed, algae, debris and had foul-smelling water **(**Fig. 2). In this type of the breeding sites, a total of 19,641 larvae (10.0% of mosquitoes collected from all types of breeding sites) were collected. Data presented in Table 1 revealed that density was 136.4 larvae were collected from drainages, where the mean values of

water temperature, pH, Ammonia, Nitrate, salinity and dissolved oxygen were 24.1 °C, 6.7 pH, 1.56 mg/l, 61.4 mg/l, 2.18 ppt and 6.6 mg/l, respectively (Table 4). *Culex pipiens* was the most common species in this site, where the relative abundance was 47.4% (9316) followed by *Cs. longiareolata* 41.7% (8186), *Cx. antennatus* 6.2% (1217), *Cx. decens* 3.0% (582) and *Cx. vagans* 1.7% (340), (Table 2).

8. Catch basins are similar to storm drains that line streets to carry away rain water. They are underground vault-like structures that slow down and hold waste water. Catch basin had large amounts of debris, organic matters and foul-smelling colored stagnant water (Fig. 2). In this breeding site, a total of 17,998 larvae (9.2% of mosquitoes collected from all types of breeding sites) were collected. Data presented in Table 1 revealed that density was 187.5 larvae were collected from catch basins, where the mean values of water temperature, pH, Ammonia, Nitrate, salinity and dissolved oxygen were 25.1 °C, 6.2 pH, 1.94 mg/l, 72.4 mg/l, 2.38 ppt and 3.5 mg/l, respectively (Table 4). *Culex pipiens* was the most common species in this site, where the relative abundance was 80.4% (14467) followed by *Cs. longiareolata* 19.6% (3531), (Table 2).

9. Irrigation basins are artificial site that receive the irrigation water from canal to irrigate the cultivated fields. They are constricted up or underground vault-like structures. The bottom of irrigation basins had materials such as rocks, gravels and debris (Fig. 2). In this breeding site, a total of 7,843 larvae (4.0% of mosquitoes collected from all types of breeding sites) were collected. Data presented in Table 1 revealed that density was 81.7 larvae were collected from irrigation basins, where the mean values of water temperature, pH, Ammonia, Nitrate, salinity and dissolved oxygen were 23.5 °C, 7.3 pH, 0.47 mg/l, 28.5 mg/l, 1.28 ppt and 6.8 mg/l respectively (Table 4). *Culex antennatus* was the most common species in this site, where the relative abundance was 53.1% (3966) followed by *Cx. pipiens* 40.9% (3408), *Cx. perexiguus* 3.4% (269) and *Cx. univittatus* 2.6% (200), (Table 2).

10. Ditches are a small long and narrow channel or a set of trenches, characterized by simple structure. This type of the breeding sites was distributed in all villages investigated especially in densely populated areas, whereas the village dwelling used it as storm drains. Ditches are usually neglected places with chocking vegetation, debris and animal dead (Fig. 2). In this breeding site, a total of 11,228 larvae (5.7% of mosquitoes collected from all types of breeding sites) were collected. Data presented in Table 1 revealed that density was 58.5 larvae were collected from ditches, where the mean values of water temperature, pH, Ammonia, Nitrate, salinity and dissolved oxygen were 22.3 °C, 7.2 pH, 0.51 mg/l, 27.4 mg/l, 1.1 ppt and 7.8 mg/l, respectively (Table 4). *Culex pipiens* was the most common species in this site, where the relative abundance was 65.8% (7385) followed by *Cx. antennatus* 16.2% (1820), *Cs. longiareolata* 13.4% (1502) and *Cx. vagans* 4.6% (520), (Table 2).

11. Temporary pools are temporary breeding sites with colored and stagnant water that usually dry in hot months. This site was found in open areas, streets, yards and other places inside villages and cities (Fig. 2). In this type of the breeding sites, a total of 5,329 larvae (2.7% of mosquitoes collected from all type of breeding sites) were collected. Data presented in Table 1 revealed that density was 37 larvae were collected from temporary pools, where the mean values of water temperature, pH, ammonia, nitrate, salinity and dissolved oxygen were 22.4 °C, 6.8 pH, 0.48 mg/l, 21.7 mg/l, 0.78 ppt and 6.1 mg/l, respectively (Table 4). *Culex pipiens* was the most common species in this site, where the

relative abundance was 71.9% (3830) followed by *Aedes caspius* 23.1% (1229) and *Cx. vagans* 5.1% (270), (Table 2).

12. Swamps are deep lowland and waterlogged area adjacent to ponds or irrigation lands. These breeding places are usually shaded and characterized by natural vegetation, highly organic materials **(**Fig. 2). In this type of the breeding sites, a total of 7,783 larvae (4.0% of mosquitoes collected from all types of breeding sites) were collected. Data presented in Table 1 revealed that density was 54.1 larvae were collected from swamps, where the mean values of water temperature, pH, Ammonia, Nitrate, salinity and dissolved oxygen were 20.5 °C, 7.2 pH, 0.49 mg/l, 36.8 mg/l, 1.5 ppt and 7.1 mg/l, respectively (Table 4). *Aedes caspius* was the most common species in this site, where the relative abundance was 55.3% (4305) followed by *Cs. longiareolata* 23.7% (1848), *Cx. vagans* 7.7% (600), *Cx. pipiens* 5.8% (450), *Anopheles multicolor* 4.5% (350) and *Cx. antennatus* 3.0% (231), (Table 2).

13. Unused tires (Track tires) are suitable mosquito breeding sites, where the stagnant water in the full-casing tire and dark were present (Fig. 2). In this breeding site, a total of 406 larvae (0.2% of mosquitoes collected from all types of breeding sites) were collected. Data presented in Table 1 revealed that density was 8.5 larvae were collected from tires, where the mean values of water temperature, pH, Ammonia, Nitrate, salinity and dissolved oxygen were 15.5 °C, 6.5 pH, 0.41 mg/l, 23.8 mg/l, 0.84 ppt and 6.4 mg/l, respectively (Table 4). *Aedes caspius* was the most common species in this site, where the relative abundance was 78.6% (319) followed by *Cx. vagans* 21.4% (87), (Table 2).

14. Irrigation drainage tubes are vertical drainage tube distributed in agriculture lands. These sites are storm drains, which receive the drains water from agriculture lands to drainage (Fig. 2). In this type of the breeding sites, a total of 238 larvae (0.1% of mosquitoes collected from all types of breeding sites) mosquito larvae were collected. Data presented in Table 1 revealed that density was 5 larvae were collected from irrigation drainage tubes, where the mean values of water temperature, pH, Ammonia, Nitrate, salinity and dissolved oxygen were 15.5 °C, 7.1 pH, 0.41 mg/l, 23.8 mg/l, 0.84 ppt and 6.4 mg/l, respectively (Table 4). *Culex pipiens* was only species collected in this site (Table 2).

Duncan's multiple range test for variable between type of the breeding sites and density of mosquito larvae showed that there was a significant variation between the density of mosquito larvae and type of the breeding site (df= 13, F= 149.26, P= 0.0001). The breeding sites were organized dissentingly according to the highest mean ±SD (Table 3).

Table 3: Density (No. of larvae/dip) of mosquito larvae at breeding habitats surveyed in eight villages, Qalyubiya Governorate from April 2009 to March 2011.

Type of breeding habitats	Mean ± SD	df	F value	Significant (*P*)
Catch basin	187.5±65.9a	47	149.26	0.0001
Unused well	145.0±59.8b	119		
Drainage	136.4±71.0b	71		
Pond	118.9±41.0c	71		
Irrigation channel	105.1±66.3d	95		
Pool	103.4±58.3d	119		
Irrigation basin	81.7±54.8e	47		
Canal	77.7±48.3e	167		
Ditch	58.5±34.5f	95		
Swamp	54.1±35.6f	71		
Temporary pool	37.0±28.0g	71		
Rice field	19.1±10.5h	72		
Unused tire	8.5±10.6h,i	23		
Irrigation drainage tubes	5.0±3.4i	23		

Means followed by the same letters aren't significantly different (p>0.05) using Duncan's multiple range test in SAS.

Physicochemical properties of breeding places.

Physicochemical parameters of breeding places are summarized in Table 4. Further, observations showed that vegetation was present in almost all habitats. Catch basins and ponds were very turbid while unused tires and irrigation drainage tubes were light-turbid or clear. Accumulated organic debris from dead organisms or decaying plants were often important sources of nutrients to mosquito larvae, where the debris was very high in catch basins, drainages and unused wells. The relation between mosquito larvae densities and prevailed water conditions namely temperature, pH, Ammonia, Nitrate, salinity and dissolved oxygen was assessed using Correlation, Simple and Multiple regression analysis (Table 5).

Table 4: Physicochemical characteristics of mosquito larval habitats surveyed in eight villages of Qalyubiya Governorate from April 2009 to March 2011.

Type of the breeding site	**Characteristics of habitats sampled**					
	*Temperature	*pH	*Ammonia mg/l	*Nitrate mg/l	*Salinity ppt	*Dissolved O_2 mg/l
Canal	21	8.6	0.38	25.6	1.18	9.2
Pool	23.8	6.4	0.88	42.2	1.67	6.8
Temporary pool	22.4	6.8	0.48	21.7	0.78	6.1
Unused well	24.5	7.5	1.32	66.4	1.74	7.4
Irrigation channel	21.6	7.4	0.64	35.6	1.29	8.4
Drainage	24.1	6.7	1.56	61.4	2.18	6.6
Catch basin	25.1	6.2	1.94	72.6	2.38	3.5
Ditch	22.3	7.2	0.51	27.4	1.1	7.8
Pond	24	6.8	0.91	44.2	1.73	7.1
Irrigation basin	23.5	7.3	0.47	28.5	1.28	6.8
Unused tire	15.5	6.5	0.41	23.8	0.84	6.4
Irrigation drainage tubes	19	7.1	0.44	21.8	1.52	7.4
Rice field	23.5	8.2	0.57	30.1	1.62	8.6
Swamp	20.5	7.2	0.49	36.8	1.73	7.2

* Average values for all breeding sites throughout the whole period of study.

Table 5: Correlation, simple and multiple regression analysis model associating prevailed water conditions with mosquito larvae densities at breeding habitats surveyed in eight villages, Qalyubiya Governorate from April 2009 to March 2011.

Predictor variable	Correlation	Simple regression		Multiple regression values				
	r	b	P	b	P	F value	P	R^2
Temperature	0.73044	15.57	0.0030	9.72	0.0397	12.036	0.0037	0.9335
pH	-0.34113	-34.01	0.2326	-35.92	0.1394			
Ammonia	0.87706	5.60	0.0001	13.34	0.0241			
Nitrate	0.89672	3.08	0.0001	5.04	0.0040			
Salinity	0.65438	77.56	0.0111	-60.54	0.0550			
Dissolved O_2	-0.42810	-17.31	0.1267	19.79	0.1332			

Densities of mosquito larvae were positively correlated with temperature, Ammonia, Nitrate and salinity (r^2 = 0.5335, 0.7692, 0.8041 and 0.485), respectively, whereas no correlation was found between mosquito larval densities, pH and dissolved oxygen where (r^2 = 0.1164 and 0.1833), respectively (Fig. 3). Simple and multiple regression analysis revealed that the model was significant with temperature, Ammonia and Nitrate where (Adjusted r^2 = 0.4947; df = 1; F = 13.726; P = 0.003), (Adjusted r^2 = 0.7500; df = 1; F = 40.003; P = 0.0001) and (Adjusted r^2 = 0.7878; df = 1; F = 49.259; P = 0.0001) respectively. While, the model was significant with salinity in simple regression analysis, where

(Adjusted $r^2 = 0.3806$; df = 1; F = 8.987; P = 0.011). According to the developed model, only temperature, Ammonia and Nitrate could be used as a predictor variables for mosquito larvae densities (β = 9.72; *P* = 0.0397), (β = 13.34; *P* = 0.0241) and (β = 5.04; *P* = 0.0040) (Table 5).

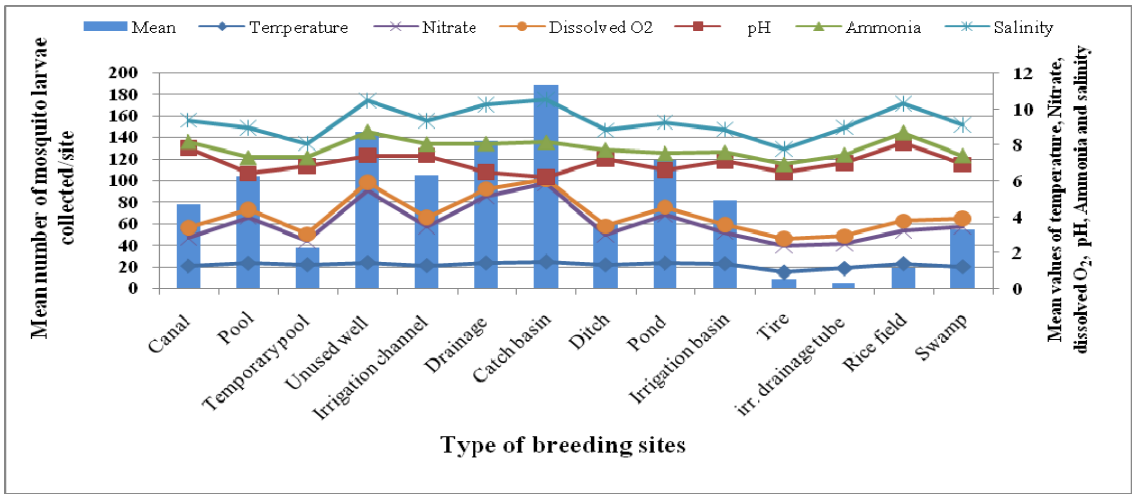

Fig. 3: Density of mosquito larvae at breeding habitats surveyed in relation to monthly mean of temperature, Nitrate, dissolved O_2, pH, Ammonia and salinity in eight villages, Qalyubiya Governorate from April 2009 to March 2011.

DISCUSSION

The situation of Qalyubiya Governorate in Southeastern of the Nile Delta and the diversity of villages provide ample habitats for mosquitoes to breed and thrive. Permanent and semi-permanent water collections were found the main sites for mosquito breeding in Qalyubiya Governorate including unused wells, drainages, ponds, canals, pools and swamps.

Unused wells or sakia pits, drainages, pond, pools, canals, irrigation channels, rice fields and swamps are widely distributed in the study area and were found the most important breeding habitats for many species of mosquitoes. While, irrigation basins, ditches, temporary pools, irrigation drainage tubes and unused tires were less distributed in the study area. Unused wells or sakia pits may play an important role in mosquito breeding because they are distributed throughout the whole Governorate, inaccessible, rarely dried up throughout the whole year, contain relatively high density of mosquitoes and need big time to reach by spray men even in a small area. The role of unused wells or sakia pits in mosquito breeding have been recorded by Mahdi *et al.*, 1963; Shawarby *et al.*, 1968; Mohamed *et al.*, 1981; Hilmy *et al.*, 1987 and Kenawy *et al.*, 1996.

Eight Culicine and one Anopheline mosquito species were recorded throughout the two years of the study namely: *Culex pipiens*, *Culiseta longiareolata*, *Cx. antennatus*, *Aedes caspius*, *Cx. vagans*, *Cx. decens*, *Cx. perexiguus*, *Cx. univittatus* and *Anopheles multicolor*. Some species recorded in the present study were collected from Qalyubiya by earlier investigators as Kirkpatrick 1925 who recorded 22 species but *Cx. antennatus*, *Cx. vagans*, *Cx. decens* and *Cx. univittatus* were not encounted in his investigation; El Said and Kenawy (1983) in their survey recorded seven species, *Culex pipiens*, *Cx. antennatus*, *Cx. pusillus*, *Cx. poicilipes*, *Aedes caspius*, *Culiseta longiareolata* and *Cs. unguiculata* but *Cx. vagans*, *Cx. decens*, *Cx. perexiguus*, *Cx. univittatus* and *Anopheles multicolor* were not encounted

in their investigation*;* Hilmy *et al.* (1987) recorded eight species but they did not collect *Cx. vagans*, *Cx. decens*, *Cx. perexiguus* and *Anopheles multicolor*, which were collected in our study; Soliman 1985 recorded *Culex pipiens*, *Cx. antennatus, Cx. univittatus, Culiseta longiareolata, Aedes caspius, Anopheles pharoensis* and *An. tenebrosuis* and Morsy *et al.* (2004) recorded *Culex pipiens*, *Cx. perexiguus, Cs. longiareolata* and *Ae. caspius*, *Cx. pusillus* and *Cx. perexiguus*. From the results, it was observed that *Culex vagans*, *Cx. decens* and *Anopheles multicolor* were not recorded before in Qalyubiya Governorate except (*Anopheles multicolor*) were recorded by Kirkpatrick 1925.

Most breeding habitats surveyed were inhabited with *Culex pipiens* larvae. This species accounted 64.7% of the total larvae collected from all areas selected in the present survey. The high abundance and distribution of *Culex pipiens* in most breeding places of Egypt was also observed by many investigators as: Kirkpatrick 1925, Shawarby *et al.,* 1968, Hilmy *et al.,* 1987, Mohamed *et al.,* 1981 and 1994, Soliman 1985, Harbach 1988 and Khater and Shalaby, 2008. *Culex antennatus* was the second and most common mosquito species in most breeding habitats and in all areas of study. This species was found in association with *Cx. univittatus* and *Cx. perexiguus* especially in unused wells, irrigation basin and rice fields. Gad, 1956; Rifaat *et al.,* 1969; Mohamed *et al.,* 1981, Soliman 1985 came to the same conclusion. Rice fields were found a suitable breeding habitat for all mosquito species recorded except *Culiseta longiareolata* and *Aedes caspius*. Rice fields were the most prolific breeding site for *Culex antennatus*, *Cx. univittatus*, *Cx. perexiguus* and *Anopheles multicolor*. Similar findings were reached by Wassif, 1969 and Rifaat *et al.,* 1971 in the Nile Delta and Kaschef *et al.,* 1982 in Sharkiya Governorate. A close association was found between *Cx. pipiens* and *Culiseta longiareolata* in most breeding places surveyed. Similar finding was reported by Wassif (1969). The high prevalence of *Culiseta longiareolata* in the present study compared with the results of other authors in other Governorates may be due to more suitable environmental and breeding conditions and/or the prevalence of animal hosts of this species in Qalyubiya Governorate. Water collections that receive seepage, foul-smelling water such as drainage, pool and pond were the preferred sites for the breeding of *Ae. caspius* larvae. Clean and fresh water habitats as rice fields, canals and large clean swamps was inhabited with low densities of *Anopheles multicolor* which was the only anopheline species recorded during the present study. The scarcity of anopheline species in Qalyubiya Governorate was also reported by Kirkpatrick 1925 and Hilmy *et al.,* 1987. Small, turbid water collections were found suitable breeding habitats for larvae of *Culex vagans* and *Cx. decens* such as pools, drainage, temporary pools and unused wells.

We can conclude that in Qalyubiya Governorate, mosquito larvae breed in a wide range of breeding places (14 types), shaded, semi-shaded and sunlight exposed areas with various width (0.5-1.5 meter) and mostly shallow depth (5-50 cm) with or without visible vegetations (algae, emerging and stand plants) and with or without visible turbidity and at temperature ranges between 13-30°C. Similar findings were found by many investigators as Theobald (1901) who stated that mosquito larvae seem to prefer shallow water especially where there is a good growth of green algae; Abd El-Magid (1987) recorded, the presence of particularly culicine mosquito larvae in drainage channels, cesspools and seepage pools with turbid

and slightly turbid stagnant width between 0.3-5 meter, emergent vegetations and in semi-shaded sites. Hopkins (1936) attributed the presence of mosquito larvae in places exposed to sunlight to the presence algae which represent an important food for larvae and may aid in maintaining balance of dissolved of gasses and in utilizing organic materials favorable for the larvae. Whereas, Horsfall (1955) pointed out that light is not essential for development of certain mosquito species as *Culex molestus, quinquefasciatus* and *pipiens*.

Mosquito larvae were found in habitats with a relatively wide range of temperature (14 to 29 °C). Tolerance of larvae to a relatively wide range of temperature was also reported by Kenaway and El-Said (1989). The authors collected nine mosquito species in Egypt breeding in water temperature ranging between 16-39°C. The actual selection of the mosquito habitat is probably made in the evening or night by the ovipositioning female, at a time when temperature may be quite different (Thomson, 1940). Moreover, temperature conditions in aquatic environment are, in general, much more stable than in aerial environments (Bates, 1949). Meanwhile, permanent high temperature over 30°C reduce the average life of mosquito population (WHO, 1975).

Our results reveled that larvae of all mosquito species collected in the study area are of alkaline tendency (6.4-9.5). However, pH 6.4 was restricted to only one type of breeding places where only *Aedes caspius* and *Cx. pipiens* were encountered. The alkaline tendency (pH 7.8-9.5) of mosquito larvae in Qalyubiya Governorate have been also reported by many Egyptian investigators as Hilmy *et al.,* 1987 in Qalyubiya; Gad and Salit (1972) in Red Sea area, and Hamdy (1987) in Ismailia.

Although Mosquito larvae were found in different types of breeding places with different salinities (0.78-2.38 ppt), our results declared a difference between the mosquitoes fauna of fresh and latrine/brackish waters. Kirkpatrick (1925) classified the mosquitoes of Egypt to purely fresh water breeders and purely salt water and more or less indifferent. Beadle (1939) found that larvae of *Aedes detritus* could regulate both the total osmotic pressure and the chloride content of haemolymph in water of varying salinity. In Akrasha village *Aedes caspius* was the only species associated with *Cx. pipiens* in water accumulation in pool foul-smelling with salinity up to 1.67 ppt.

Our results declared that mosquito larvae, especially *Cx. pipiens* can tolerate various degrees of water pollution as indicated from ammonia and nitrate content of mosquito larval breeding places (1.94 mg/l and 72.4 mg/l, respectively). Bates (1949) pointed out that the most obvious characteristics of polluted water are the high content of nitrate and even nitrite. Brink and Das Chowdhury (1939) found that all fourth instar larvae of *An. stephensi* had died in concentration of ammonium sulfate higher than 0.5% while larvae of *Cx. quinquefasciatus* pupated normally in concentration of 1.5% but the first instar larvae of *Cx. quinquefasciatus* were more sensitive dying in a concentration of 1%. During our study we never collected *Anopheles* species from mosquito breeding places containing high salinity such as canals and rice fields (1.18 ppt to1.62 ppt, respectively).

The predominance of *Culex pipiens* larvae in our study can be attributed to its tolerance to high pollution, salinity level and temperature with low level in dissolved oxygen in breeding sites as compared with other mosquito species.

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Fig. 2: Mosquito larval breeding habitats surveyed in the present study of Qalyubiya Governorate. (1) canal, (2) pool, (3) unused well, (4) rice field, (5) irrigation channel, (6) pond, (7) drainage, (8) catch basin, (9) irrigation basin, (10) ditch, (11) temporary pool, (12) swamp, (13) unused tire and (14) irrigation drainage tube.

ARABIC SUMMARY

مصادر توالد البعوض فى محافظة القليوبية، مصر.

عبد الوهاب عبد المقصود إبراهيم - ألفت محمد المنيرى - ياسر عفيفى السيد - محمد محمود بـاز
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تم مسح 2821من تجمعات المياه التي قد توفر مكانا لتكاثر البعوض في محافظة القليوبية خلال الفترة من ابريل 2009 الى مارس 2011 ووجد أن 1800 منها (63.8 ٪) ايجابيا لتكاثر البعوض، وتم العثور على يرقات البعوض في مجموعة متنوعة من تجمعات المياه المؤقتة والدائمة الطبيعية والتي صنعها الإنسان. وكانت تجمعات المياه الدائمة وشبه الدائمة هي المواقع الرئيسة لتكاثر البعوض، وقد تم جمع الأطوار غير الكاملة للبعوض من 312 ترعة ، 271 بركة ، 191 بئر غير مستخدمة، 166 حقل أرز، 142 قناة ري، 130 بركة عميقة، 128 مصرف، 115 حوض صرف صحي ، 85 حوض ري، 82 خندق (قناة صغيرة)، 70 مستنقع، 66 بركة مؤقتة، 22 إطارغير مستخدم و 20 أنبوبة صرف زراعي. وتم اختيار 14 مكان توالد في ثماني قرى لجمع يرقات البعوض منها شهريا. و تم خلال هذا المسح جمع تسعة أنواع من البعوض، هي كيولكس بيبنز (64.7 ٪)، كوليسيتا لونجيرولاتا (13.5٪)، كيولكس أنتناتس (8.8 ٪) ، أيدس كاسبيس (6.3 ٪) ، كيولكس فيجنس (2.5 ٪)، كيولكس ديسنس (1.9 ٪)، كيولكس بريكيجيس (0.9٪)، كيولكس يونيفتاتس (0.8٪) وانوفيليس ملتيكلر (0.6 ٪). وأظهرت نماذج الانحدار البسيط والمتعدد ارتباطا بين كثافة يرقات البعوض ودرجة الحرارة ووتركيزالأمونيا والنترات (P = 0.0397) ، (P = 0.0241) و (P = 0.0040) على التوالي. ويؤشر وجود يرقات البعوض على مدار السنة إلى أن الظروف المناخية للمنطقة لا تحد من تكاثر معظم أنواع البعوض السائدة. وأبانت الدراسة أن أحواض الصرف الصحي والآبار غير المستخدمة والمصارف تلعب الدورالرئيس في مشكلة البعوض في محافظة القليوبية.