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The impact of some environmental factors on the abundance of mosquitoes larvae in certain localities of Sharkia Governorate in Egypt

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ABSTRACT

Mosquitoes play a major role in diseases transmission and distributions, such as filariasis and malaria. The understanding of environmental factors that affect their larval abundance is a key factor for their control. Thus this study aims at investigating mosquitoes' larval abundance in a region known to be endemic for malaria mosquitoes' related diseases in Sharkia Governorate. Measuring environmental factors were: pH, total dissolved solids "TDS", turbidity, water and air temperatures, relative humidity, wind speed, water hyacinths, sun light, water flow, and width and depth of drains in relation with these environmental factors on larval abundance. Six mosquitoes species were recorded and identified in different locations from study sites of 9 drains: Abu Kbeer, Dyarb Negm and Al-Zakazik. *Culex pipiens, Culex perexiguus, Culex antennatus, Culex pusillus*, *Culex sinaiticus* and *Ochlerotatus detritus* were found to be dominant in these localities. *Culex pipiens* was the most dominant species (79.79%) in all localities. Results were shown and discussed in detail.

Keywords: Mosquitoes, survey, abundance, environmental factors, Sharkia governorate, Egypt

INTRODUCTION

Mosquitoes are considered a very important vector for filariasis and malaria. Filariasis is a widespread disease in Sharkia Governorate (Shawarby *et al.,* 1965 and Kaschef *et al.,*1982) and transmitted mainly by *Cx. pipiens*. Malaria has an old history as the only outbreak of malignant (*falciparum*) malaria occurred in the Nile Delta (Farid, 1940).

Understanding of mosquitoes bionomics is of key importance in the epidemiology of mosquito-borne diseases and in planning methods of mosquitoes control. Climatic factors play an important role in species distribution, behavior, survival and vectorial status. Water is an essential component of the mosquitos' environment and whether it is running, standing, clean or polluted, sweet or brackish, shaded or sunlight, frequently determines which species of mosquitoes breeds in it. The environments of the immature stages and adult mosquitoes are interdependent since the adult mosquitoes must have access to water for egg laying. (WHO manual of mosquitoes control, 1988).

Cx. pipiens was the main vector disease of human for filariasis in Egypt (Gad *et al*., 1987). *Wuchereria bancrofti* has been endemic in Egypt since pharaonic times (Laurence, 1967), and it was considered as a major health problem throughout the first half of the 20th century (Baz, 1946).

Six species of mosquitoes were previously reported in Sharkia: *Cx. pipiens* Linnaeus, *Cx. perexiguus* Theobald, *Cx. antennatus* (Becker), *Cx.* (*Barraudius*) *pusillus* Macquart, *Cx. sinaiticus* Kirkpatrick and *Aedes (Ochlerotatus) detritus*

(Haliday). The last two were identified as newly distributed species. *Cx. pipiens,* was the most common species. (Abdel-Hamid *et al.,* 2009).

Cx. pipiens breeds in seewage canals and drains, wells and cesspits, but not in rice fields in which *Cx. antennatus* prefers as breeding habitat. *Cx. antennatus* breeds also in the same breeding sites of *Cx. pipiens***,** *Cx. univittatus* breeding habitats were found to resemble more or less those of *Cx. antennatus.* On the other hands, *Theobaldia longiareolata* larvae were recovered from the same breeding sites of *Cx. pipiens.* Rice fields were found also negative for this species. Wassif (1969) stated"*Ae. caspius* breeds in seepage, canals and drains".

Anopheles pharoensis was present in summer and autumn, *Uranotaenia unguiculata* from October to December; *Culiseta longiareolata* from December to June (with a peak in March), *Ae. caspius* in late autmn and winter; *Cx. pusillus* from September to November, *Cx. perexiguus* from September to November, *Cx. pipiens* which was so numerous throughout the year that it was difficult to determine its seasonal peak. (Kirkpatrick, 1925).

Sharkia Governorate covers about 4911 km² at the east of Nil Delta with a population of 5,354,041 inhabitants (2010 public census). Sharkia bordered from the north by El Manzlah Lake, from the east by Ismailia, from south by Al Qalyubiah and from west by El Daqahliyha. It represents various topographic areas including agricultural, semi desert, and desert areas. It contains 15 towns and over 4000 villages with various human activities.

The agricultural drainage water reuse is defined as the use of water discharge repeatedly, source "Nevada's Water Dictionary" (Mostafa *et al.,* 2004). The degraded water quality threatens the expansion and even the continuation of the reuse of drainage water from the main drains in the Nile Delta. (Hussein *et al.,* 2008).

The objective of the present study is to evaluate the effect of some environmental factors on the mosquitoes larvae abundance. The former was undertaken in selected sites in one of our Governorates, Sharkia, known to have plenty of mosquitoes habitats and this may have an influence on man's hygiene.

MATERIALS AND METHODS

The study sites

Work was carried out from April to June 2012 in different mosquitoes breeding sites in Sharkia Governorate. Nine drains in three different cities were selected to conduct this study, Figs. 1&2.

Fig. 1: Map of Sharkia Egypt

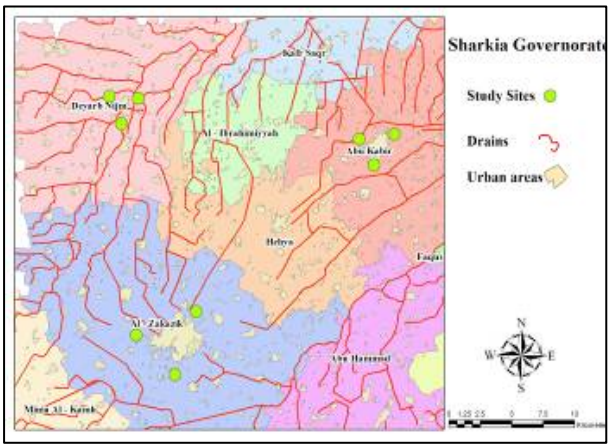

Fig. 2: Map of the study area

Habitat characterization

Classification of aquatic habitats based on their size and appearance. Emergent vegetation cover was defined as the proportion of the water surface area that was covered by emergent vegetation. Floating vegetation cover was estimated as the proportion of the water surface area that was covered by floating vegetation. Any plant below the water surface was classified as submerged vegetation, and the proportion of water surface area covered by this vegetation was estimated (Ephantus *et al.,* 2007)

Larval surveys

Larval surveys were carried out for three monthes (April, May and June 2012). Larvae were collected by aquatic net having half circular net with 45 cm diameter fixed at the end of a long stick. After collection, larvae were kept in 70% ethyl alcohol in glass vials, labeled and transferred to the laboratory for classification. Keys given by Kirkpatrick (1925) and Harbach (1988) were used for mosquitoes identification.

Environmental factors measurements

Parameters that measured for each sample; pH, Total Dissolved Solids (TDS) and turbidity. Other water parameters were taken in site of collection: water & air temperatures, percent of relative humidity (RH), wind speed, water hyacinths capacity, sun light, water flow speed, width and depth of drains.

Geographical information system mapping

Digital map of Egypt was obtained from Geographic information system unit (GIS) in Egyptian ministry of environmental affairs agency (EEAA), appearing various divisions of Egypt with different feature classes for drains, rivers and roads. Coordinate system used in digital maps was GCS_WGS_1984 and Datum D_WGS_1984. Computer program Arc view 9.1 was used for producing maps showing distribution of mosquitoes larvae in the Governorate.

Data analysis

The SSP (Smiths Statistical Package, version 18) computerized program was used for statistical analysis. Means, standard deviations and standard errors, were calculated for larval densities of mosquitoes species. Means were compared by the one-way ANOVA and if significantly different, they were exposed to pairwise comparison by Tukey test. Multiple Regression analysis was used to examine the relation of larval density to some environmental variables of the breeding water.

RESULTS

a- Relative abundance of mosquitoes species

Mosquitoes larvae were collected from nine sites in three towns in Sharkia Governorate Table 1. A total of 3572 larvae were recorded of which the lowest number of larvae was 27 larvae in site 9 (0.8%) and the highest number of larvae was 764 in site 3 (21.4 %). Mosquitoes larvae were higher in Abu Kbeer (1710 Larvae) than in the other towns.

Fig. 3 shows that Abu Kbeer was highest (ca. 47.87 %, 1710 larvae) Al-Zakazik (ca. 27.29 %, 975 larvae) and comparing by Dyarb Negm (ca. 24.84 %, 887 larvae).

Table 1: Mosquitoes larvae species abundance that found in sites of collection in Sharkia Governorate

Town	Abu Kbeer			Dyarb Negm			Al-Zakazik			Total	Percent
Site	1	2	3	4	5	6	7	8	9		
C.pipiens	361	381	642	18	129	533	272	497	17	2850	79.79%
Cx.antennatus	36	71	75	8	16	83	31	77	1	398	11.14%
Cx.perexiguus	23	44	35	0	5	58	16	33	4	218	6.10%
Cx.pusillus	7	11	10	5	6	14	4	16	3	76	2.13%
Oc.detritus	5	4	2	0	0	3	2	0	2	18	0.50%
Cx.sinaiticus	1	2	0	6	0	3	0	0	0	12	0.34%
Total larvae	433	513	764	37	156	694	325	623	27	3572	100%
Percent %	12.1%	14.4%	21.4%	1%	4.4%	19.4%	9.1%	17.4%	0.8%	100%	
Total number in each town	1710			887			975			3572	

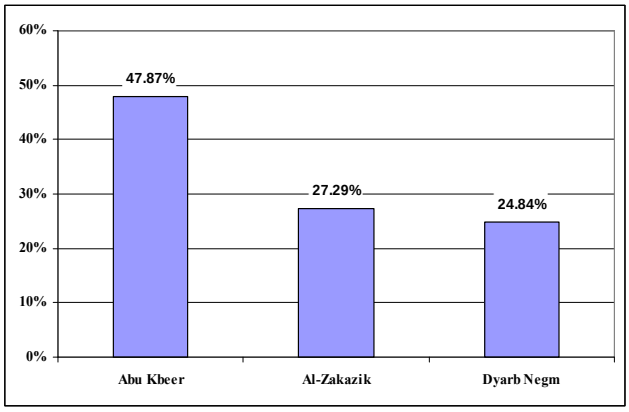

Fig. 3: Percentages of all collected mosquitoes larvae from three towns at Sharkia Governorate

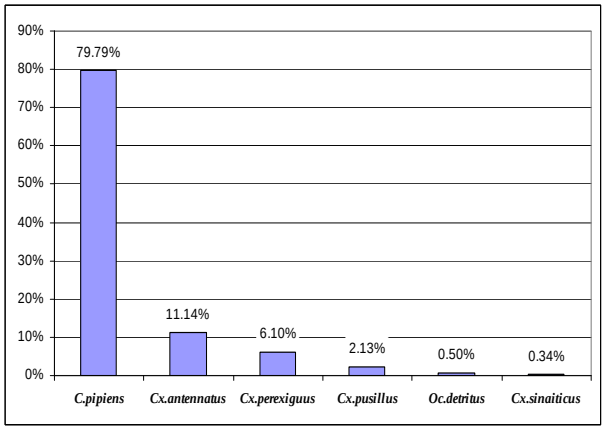

Fig. 4: Percentages of collected species of mosquitoes larvae

Six mosquitoes species were identified; *Cx. pipiens*, *Cx. perexiguus*, *Cx. antennatus*, *Cx. pusillus*, *Cx. sinaiticus* and *Oc. detritus*. Fig. 4 shows that *Cx. pipiens* was the dominant species (79.79%, 2850 larvae) compared to *Cx. antennatus* (11.14%, 398 larvae), *Cx. perexiguus* (6.10%, 218 larvae), *Cx. pusillus* (2.13%,76 larvae), *Oc. detritus* (0.50%, 18 larvae) and *Cx. sinaiticus* (0.34%, 12 larvae).

The data in Table 2 shows that larvae of different species were different in abundance in all breeding habitats; *Cx. pipiens* was the most common (105.56 ± 21.322), *Cx. antennatus* (14.74 ± 2.129), *Cx. perexiguus* (8.07 ± 1.269), *Cx. pusillus* (2.81 ± 0.506), *Oc. detritus* (0.67 ± 0.185) and *Cx. sinaiticus* (0.44 ± 0.252).

Table 2: Number and averages (SE±) of mosquitoes larvae collected during the study period

Species	No. larvae	Mean ± SE
Cx.pipiens	2850	105.56 ± 21.322
Cx.antennatus	398	14.74 ± 2.129
Cx.perexiguus	218	8.07 ± 1.269
Cx.pusillus	76	2.81 ± 0.506
Oc.detritus	18	0.67 ± 0.185
Cx.sinaiticus	12	0.44 ± 0.252

Table 3 illustrated that site 3 was the higher one according to number of larvae collected with the higher abundance rate (109.14 ± 89.41larva/site) and site 9 had the lowest larval abundance (3.86 ± 2.26 larva/site).

Table 3: Larval abundance of sites in different towns at Sharkia Governorate

Sites	Larvae Number	Mean ± SE
1	433	61.86 ± 50.10
2	513	73.29 ± 52.25
3	764	109.14 ± 89.41
4	37	5.29 ± 2.46
5	156	22.29 ± 17.92
6	694	99.14 ± 73.31
7	325	46.43 ± 37.84
8	623	89.0 ± 68.81
9	27	3.86 ± 2.26

b- Effect of some environmental variables on mosquitoes larval abundance

Data in Table 4 shows the effect of pH, TDS, turbidity, water temperature, air temperature, RH, wind speed, water hyacinths, sun light, water flow, drain width and drain depth on larval abundance.

Table 4: Multiple regression analysis for the effect of environmental variables on larval abundance of mosquitoes

Environmental variables	Coefficients	P values	Mean ± SE
pH	.370	.057	7.1815 ± .07717
TDS	.307	.120	911.19 ± 66.977
Turbidity	.470*	.013	37.7778 ± 5.14860
Water temperature ^{o}C	.300	.129	26.5556 ± .35711
Air temperature ^{o}C	.221	.269	26.3100 ± .47185
R.H	.079	.694	44.5689 ± .77746
Wind speed	.170	.396	16.5233 ± .18353
Water hyacinths	-.830 **	.006	58.8889 ± 7.14788
Sun light	.625	.072	2.44 ± .326
Water flow	.359	.343	1.33 ± .185
Drain width	-.352	.352	4.3333 ± .26554
Drain depth	-.721 *	.028	1.1259 ± .09646

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Fig. 5 indicates that pH, TDS, turbidity, water temperature, air temperature, relative humidity, wind speed, sun light and water flow have positive effects on larval abundance. Water hyacinths, width and depth of drains have negative effect on larval abundance.

Sunlight has strong positive effect on larval abundance (0.625, $p>0.05$) and relative humidity has weak positive effect on larval abundance (0.079, $p>0.05$). While pH, TDS, turbidity, water temperature, air temperature, wind speed and water flow have moderate effects on larval abundance.

Water hyacinths has strong negative effect on larval abundance (-0.830, $p<0.01$) and drain wide has the weak negative effect on larval abundance (-0.352, $p<0.01$). While drain depth has moderate negative effect.

Data in Table 5 indicates that the strongest parameter that affect abundance of *Cx. pipiens, Cx. perexiguus, Cx. antennatus*, *Cx. pusillus, Cx. sinaiticus* and *Oc. detritus* is water hyacinths, drain depth, sun light, water temperature and pH (Pearson correlation, -0.752, -0.554, -0.606, 0.571,-0.485, 0.413), respectively.

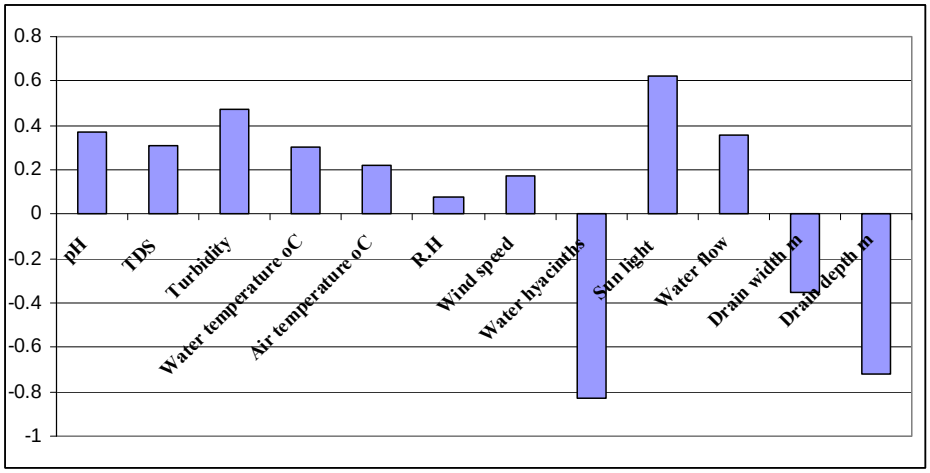

Fig. 5: Regression coefficients of some environmental variables for collected mosquitoes larvae

Table 5: Multiple regression analysis for the effect of some environmental variables on densities of different mosquitoes species

Environmental variables		*Cx.pipiens*	*Cx.perexiguus*	*Cx.antennatus*	*Cx.pusillus*	*Cx.sinaiticus*	*Oc.detritus*
pH	Pearson Correlation	.310	.545**	.571**	.470*	.024	.413*
	Sig. (2-tailed)	.115	.003	.002	.013	.907	.032
TDS	Pearson Correlation	.269	.424*	.392*	.232	.129	.020
	Sig. (2-tailed)	.174	.028	.043	.245	.520	.919
Turbidity NTU	Pearson Correlation	.431*	.540**	.542**	.280	.046	.060
	Sig. (2-tailed)	.025	.004	.004	.157	.821	.767
Water temperature °C	Pearson Correlation	.366	.024	-.029-	-.474-*	-.485-*	-.358-
	Sig. (2-tailed)	.060	.905	.886	.012	.010	.067
Air temperature °C	Pearson Correlation	.273	.039	-.016-	-.457-*	-.465-*	-.288-
	Sig. (2-tailed)	.168	.845	.938	.017	.014	.145
RH %	Pearson Correlation	.120	-.010-	-.064-	-.431-*	-.410-*	-.227-
	Sig. (2-tailed)	.552	.961	.753	.025	.034	.255
Wind speed (km/h)	Pearson Correlation	.157	.091	.133	.319	.250	.088
	Sig. (2-tailed)	.434	.652	.507	.105	.209	.663
Water hyacinths density	Pearson Correlation	-.752-**	-.413-*	-.453-*	.124	.334	.054
	Sig. (2-tailed)	.000	.032	.018	.539	.088	.789
Sun light	Pearson Correlation	.206	.204	.398*	.571**	.341	-.071-
	Sig. (2-tailed)	.303	.309	.040	.002	.082	.725
Water flow	Pearson Correlation	.203	.306	.457*	.512**	-.305-	-.042-
	Sig. (2-tailed)	.311	.121	.017	.006	.121	.837
Drain width m	Pearson Correlation	-.272-	-.056-	-.285-	-.215-	.213	.261
	Sig. (2-tailed)	.170	.783	.149	.281	.287	.188
Drain depth m	Pearson Correlation	-.517-**	-.554-**	-.606-**	-.267-	.339	.130
	Sig. (2-tailed)	.006	.003	.001	.178	.084	.517

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Figs. 6&7 indicates that all species recorded positively correlated with pH, TDS, turbidity, wind speed and sun light. Except *Cx. sinaiticus* and *Oc. detritus* all species positively correlated with water flow and negatively corelated with drain width and depth. All species negatively correlated with water temperature and air temperature except *Cx. pipiens* and *Cx. perexiguus*. All species negatively correlated with RH except *Cx. pipiens. Cx. pipiens, Cx. perexiguus* and *Cx. antennatus* negatively correlated with water hyacinths and positevly correlated with *Cx. pusillus, Cx. sinaiticus and Oc. detritus*.

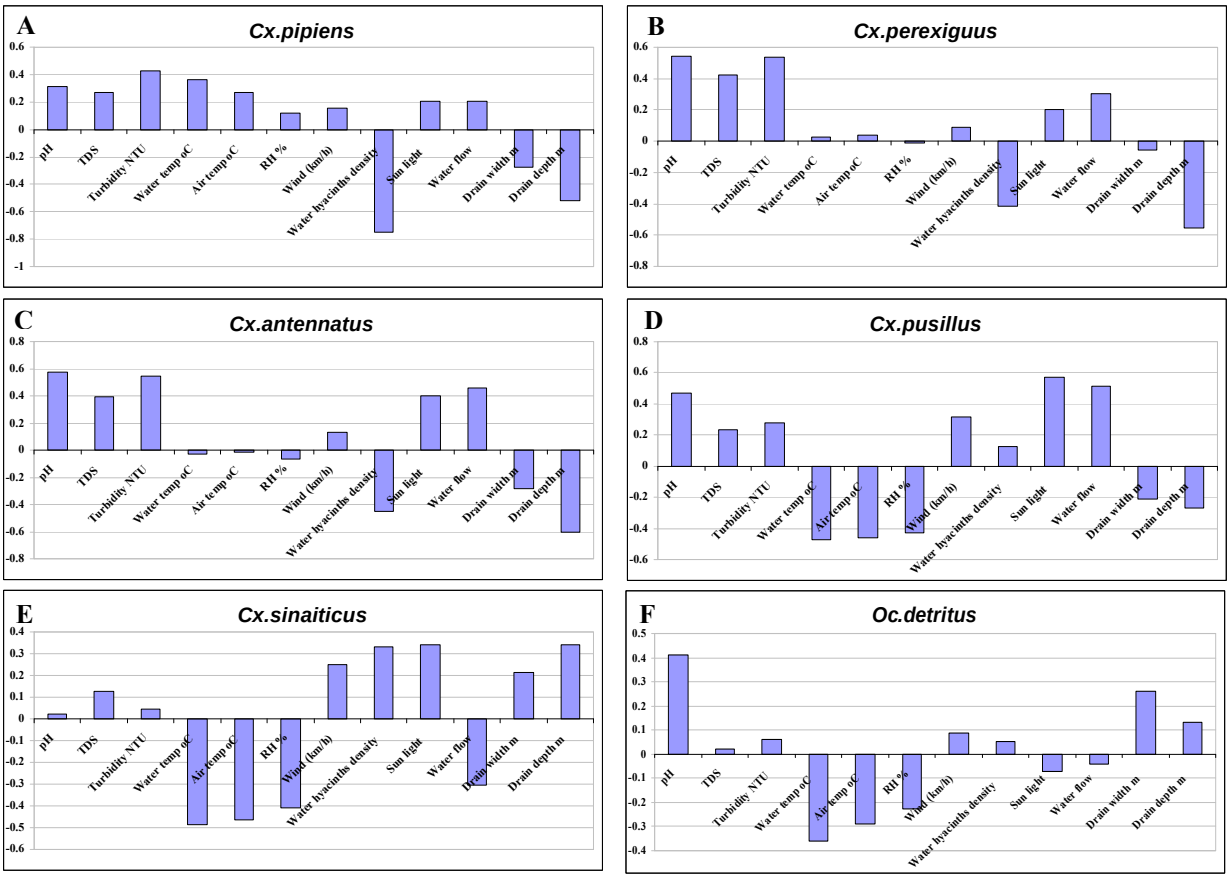

Fig. 6 (A-F): Regression coefficients of some environmental variables that affect different mosquitoes species collected during the present study.

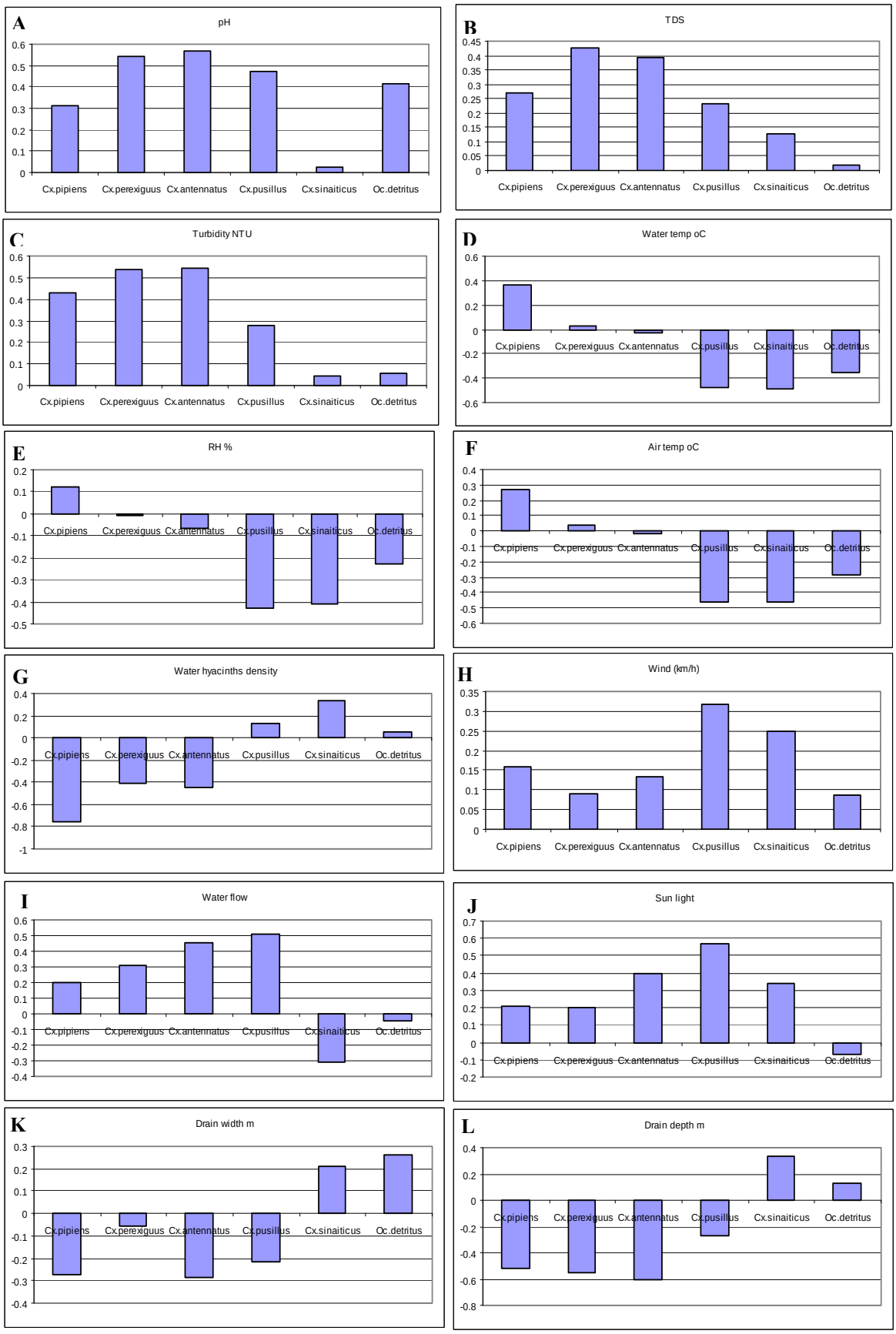

Fig. 7 (A-L): Regression coefficients of some environmental variables that affecting different mosquitoes species collected during the present study.

DISCUSSION

In the present study, six mosquitoes species were reported at Sharkia Governorate; *Cx. pipiens, Cx. perexiguus, Cx. antennatus, Cx. pusillus*, *Cx. sinaiticus* and *Oc. detritus*. However eight culicine mosquitoes species were previously reported from Sharkia governorate (Kaschef *et al.,* 1982; El-Said and Kenawy, 1983; Kenawy *et al*., 1996 & 1998; El-Bashier *et al.,* 2006 and Abdel-Hamid *et al.,*2009). The eight reported species were *Cx. pipiens, Cx. perexiguus, Cx. antennatus, Cx. pusillus*, *Cx. poicilipes*, *Ae. caspius*, *Cu. longiareolata, Ur. unguiculata*, *Cx. sinaiticus* and *Oc. detritus*.

Based on results concluded, *Cx. pipiens* was the most common species (ca. 79.79%, larvae). This is in agreement with the previous studies by Gad *et al*., (1995), Kenawy *et al.,* (1996), Abdel-Hamid *et al.,* (2009) and Tawfick, (1990). This indicates the occurrence of filaria and malaria disease vector in drains of Sharkia.

Results reported for pH, ranged from 6.4 to 7.8, are in agreement with previous ones cited by El Badry (2010) who shows that pH, ranged from 6.4 to 8. Abdel-Hamid *et al.* (2009) recorded in Sharkia pH range (7.4-8.4). Salit *et al.* (1996) reported that larvae of all mosquitoes species in Kuwait State are mostly alkalinophile. Abdel Hamid *et al.* (2011) in El Ismailia reported that larval density increases as pH increased. Bates (1949) referred to the influence of acidity on the micro biota and its often correlation with landscape type of the breeding place.

Results recoreded for TDS, ranged from 607 to 1640 ppm, were comparable to (134 to 5504 ppm) reported by Al Ahmed *et al*. (2005). The present study indicates that concentrations of TDS appear to have no intensive connection to the total abundance of all species. This disagrees with previous studies indicating that individual species may be hindered by variations in TDS (TRCA , 2007 & TRCA, 2008).

Results reported for turbidity, ranged from 21 to 100 NTU, were comparable to (3.2 to 400.7 NTU) reported by Ammar (2012) & Kenaway and El-said (1990) reported that the turbidity significantly affects larval occurrence. In this study, turbidity has a positive effect on larval abundance and this is in agreement with that of Muturi *et al*. (2007) who reported that turbidity by organic matter was positively associated with larval occurrence.

Water temperature measurements in the studied drains ranged (23 to 28.8 ^{o}C) of the breeding water and this near to with water temperature (21 to 29 ^{o}C) reported by Kenawy *et al*. (1998). Optimum temperature is said to be important for microbial growth upon preferred by mosquitoes larvae (Ramachandra , 1984). Reduced temperatures cause a decline in microbial growth which increases the larval development time exposing them to greater risks of contact with potential predators and competitors (Ramachandra, 1984).

Results indicated that relative humidity has a weak positive effect on larval abundance. This goes in agreement with Rozilawati (2007) who stated that high relative humidity has little impact on eggs development. These results disagreed with Horsfall (1955) who reported that high relative humidity can give high hatching rates and low relative humidity can provide negative impact on egg hatching .

As for results reported for wind speed, ranged from 4.2 to 4.7 m/s, they are in agreement with Service (2000) who stated that slow velocity winds are important as they allow female mosquitoes to place their eggs calmly without disturbance in water containers.

Drains with higher floating vegetation (water hyacinths) have lower larval abundance. This disagreed with Walton *et al*. (1990) who found that biotic factors like vegetation are being better predictors of larval abundance. Greenway *et al*. (2003) mentioned that the presence of vegetation and floating plants provide optimal breeding conditions by acting as food sources as well as shelter from predators. Vegetation also creates stagnant conditions by decreasing water movement. Present results indicated that all mosquitoes prefer stagnant water that gives secure area. This is in agreement with that of Abdel-Hamid *et al*. (2011) and Kenawy *et al*. (1996) who observed that stagnant water was generally preferable for larval breeding. Abd-El-Magid (1987) recorded that particularly culicine mosquitoes larvae are existed in drainage channels with stagnant water.

Sunlight has strong positive effect on larval abundance likewise Hopkins (1936) that stated "sunlight has favorable effect on mosquitoes larval population for the requirement of algae for larval food".

Results reported for drain width, ranged from 2 to 6 m, with lower drain width, abundance of larvae increase in agreement with Abd-El-Magid (1987) recorded the presence of particularly culicine mosquitoes larvae in drainage channels width between 0.3-5 metre. Salit *et al*. (1996) observed that *Cx. pipiens* breeds in a wide range of breeding habitats with various width (0.5- 100 m).

Results cited for drain depth, ranged from 0,5 to 2 m, with lower drain depth abundance of larvae increase are in agreement with Horsfall (1955). The later author observed that larval feeding position may be at the water surface or on the bottom and at all levels in between. Horsfall found that in comparatively deep water (56 cm), very few larvae went to the bottom to feed and Abd-El-Magid (1987) recorded the presence of particularly culicine mosquitoes larvae in drainage channels with shallow depth ranging between (5-20 cm).

Water pollutants can be used as mosquito control variables and as a bioindicator. It is proposed that more studies on the effect of physical and chemical properties of water in larval breeding sites in Sharkia Governorate are required.

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ARABIC SUMMERY

تأثير بعض العوامل البيئية على وفرة يرقات البعوض فى بعض مناطق محافظة الشرقية –مصر

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يلعب البعوض دوراًهاما فى نقل وانتشارالكثير من الأمراض. ويمكن أن يلعب تأثير العوامل البيئية على انتشار يرقات هذه الحشرات دوراً محورياً فى مكافحة هذه الحشرات. لهذا هدفت تلك الدراسة إلى بحث انتشار وفرة يرقات البعوض فى منطقة معروفة بتوطن ألامراض المتعلقة به وهى بعض مصارف محافظة الشرقية. ولقد كانت العوامل البيئية التى قياسها وذات العلاقة بانتشار العوض ما يلى: الأس الهيدروجينى،مجموع الموادالصلبة الذائبة، العكارة، درجتى حرارة الماء والهواء،الرطوبة النسبية،سرعة الرياح، ضوء الشمس،ورد النيل water hyacinths ، وعمق وعرض المصرف.ولقد أسفرت الدراسة عن تسجيل تواجد ست من أنواع البعوض فى أماكن مختلفة بتسع من المواقع بمصارف تلك المحافظة: *Culex perexiguus, Culex antennatus, Culex pusillus*, *Culex sinaiticus* و*Culex pipiens Ochlerotatus* detritus و كان النوع *Culex pipiens* هو الأكثر تواجداً (79.79%). ولقد تم عرض النتائج ونوقش ذلك بالتفصيل.