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IMPACT OF PHYSICAL AND CHEMICAL CHARACTERISTICS OF BREEDING SITES ON MOSQUITO LARVAL ABUNDANCE AT ISMAILIA GOVERNORATE, EGYPT

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Abstract

The distribution and monthly abundance of mosquito larvae in released water, drainage canals and sewage water tanks in Ismailia governorate were investigated. The results obtained indicated the presence of five culicine (*Culex. pipiens*, *Cx. pusillus*, *Cx. perexiguus*, *Cx. theleri* and *Ochlerotatus. caspius*) and two anopheline (*Anopheles. multicolor and An. pharoensis*) mosquito species. Significantly higher larval density was recorded in sewage water (n= 5534; 46.08%) as compared with released water (n= 2903; 24.17%) and drainage water (n= 3573; 29.75%). *Culex pipiens* was the most dominant mosquito species in the three habitats. The effects of environmental parameters including pH, biological and chemical oxygen demands, day time water temperature, plant growth, salinity, total organic matter and concentrations of heavy metals on larval population density were investigated. The positive correlations observed between heavy metals concentrations in the three habitats suggested relative uniformity of the sources of metal pollutants. *Culex pipiens* larvae demonstrated high tolerance to elevated levels of heavy metals in sewage water and compensatory effects of high nutrient levels generally associated with sewage or domestic waste. High densities of culicine larvae were accompanied by low density of anopheline larvae. This was attributed to water chemistry & competitive interactions.

Key words: Egypt, Mosquito, *Culex pipiens*, larvae pollutants, heavy metals

Introduction

The mosquito larval habitats, such as temporary or permanent bodies of water, can vary in quality along gradients of resources, predation and water chemistry which affect both female oviposition choice and larval survival (Clements, 1999). The study of not only the fluctuations of adult populations, but also the factors affecting larval abundance and distributions are important. Understanding of these factors is considered fundamental to the ability to predict transmission rates of certain diseases and for vector population control. Furthermore larval habitats are important determinants of adult distribution and abundance (Service 1989; 1995).

The present study aimed to investigate the influence of physical and chemical characteristics of mosquito larval breeding sites in Ismailia Governorate on both temporal and spatial variations of mosquito larval abundance.

Materials and Methods

Study localities, nature of breeding sites and larval sampling: Ismailia Governorate is located north east of Egypt at 31ºN; 30 ºS; 32.31ºE and 31.42 ºW. Three localities were selected for the study including Ismailia locality, Faied and West Kantara (Fig 1). Each of these is characterized by different water bodies serving as mosquito larval breeding places. Ismailia locality has scattered collections of released water resulting from the increase in level of ground water. Such water was found under and between buildings as shallow (10-25 cm depth), stagnant, non-turbid spots subjected to moderate and weak light with few plantations growing on its edges. Faied locality is characterized by the presence of drained canals resulting from the agricultural irrigation activities ranging from 50-100 cm in width containing greatly turbid, slowly flowing, semi shaded water characterized by growth of weed grass and floating vegetation. West Kantara contains hard tanks from 2-3 meters in depth and lined with cement layer except at the base. These tanks are built underground, behind the houses. Each tank has an upper opening through which the sewage water is collected. Such water is stagnant, turbid, subjected to faint light and without any growing plants.

Larval sampling was carried out monthly from January to December (2008) from fixed breeding sites representing the three habitats. Collected larvae from the different localities as well as water samples were put in plastic bags and transported to the laboratory for counting and identification following to Key prepared (Gad, 1963). Relative monthly larval density was estimated as the number/dip using a net dipper (WHO, 1975).

Measurement of environmental variables: Electrical conductivity (E.C.) of 5 ml saturated water samples expressed as (dsm^{-1}) was measured using conductivity meter (Richard *et al*, 1954). The hydrogen ion concentration (pH) was determined by pH meter (Page *et al*, 1982). Biological and chemical oxygen demands (D.O mg/L) were measured (APHA, 1985; AOAC, 1995). Chemical oxygen demand (COD mg/L) was used to measure the organic matter contents of water (Jackson, 1958). The total suspended solid (TSS mg/L) was determined by the glass filter paper filtration method (APHA, 1985). The heavy metals concentrations were done by Plasma Optical Emission-Mass Spectro-photometer (POEMS III), at the Central Laboratory, Faculty of Agriculture, Suez Canal University; and results were expressed as (mg/L; ppm).

Statistical analysis: The SPSS software version 11.5 was adopted. One way analysis of variance (ANOVA) and Chi-square analysis were used to compare larval densities and heavy metals concentrations in the three habitats. Results were considered significant at $P<0.05$. Pearson correlation coefficient (r) was used to test relationships between metals concentrations in the three habitats.

Fig 1: Map of different breeding sites of mosquito larval at Ismailia Governorate

Table 1: Chemical and physical characters of larval breeding sites at Ismailia G.

Type of habitat Parameters	Released water	Agricultural drainage water	Sewage water
pH	7.9	7.8	7.3
E.C.(dsm^{-1})	2.61	1.65	3.69
Salinity	698.1	277.3	198.4
Heavy metals: ppm			
Zn	0.011	0.033	0.16
Fe	0.050	0.11	0.71
Cd	0.001	0.001	0.01
Cu	0.002	0.041	0.07
Pb	0.001	0.003	0.03
Mn	0.030	0.025	0.23
TOMC	6	10	25
C0D	19	32	4
B0D	18	38	52

pH = Hydrogen ion concentration , E.C. = Electrical conductivity, TOMC =Total organic matter concentration, C0D = Chemical oxygen demand, B0D = Biological oxygen demand

Results

A total of 12010 mosquito larvae were collected from the three habitats. Where 2903 (24.17%), 3573 (29.75%) and 5534 (46.08%) from released water, drainage canals and sewage water respectively (Fig. 2). One way ANOVA showed that mosquito density in sewage water was significantly higher than other habitats ($F_{2,35}$ = 18.4 P < 0.001). Larvae collections were five species; *Culex pipiens* (n= 10776; 89.73%), *Cx. pusillus* (n=392; 3.26%), *Cx. perexiguus* (n=306; 2.55%), *Cx. theleri* (n=257; 2.13%), *Ochlerotatus caspius* (n= 83; 0.69%). Two anopheline species were *Anophles multicolor* (n=143; 1.19%) and *An. pharoensis* (n=53; 0.44%).

Cx. pipiens was the most dominant species in the three habitats (F= 22.8; P<0.001). The relative densities were 89.5%, 89.7% and 89.8% of total collected larvae (Tab. 3; Fig. 2) and their abundance significantly varied across time (Fig. 3) at various physical and chemical conditions of breeding sites (Tab. 1; Fig. 4 a, b, c).

Chi-square analysis indicated that *Cx. pipiens* larvae were more abundant in

August (X^2=204; d. f. = 11; P <0.001), October (X^2=299 d. f. = 11; P<0.001) and June (X^2=244; d. f. =11 P<0.001) in released, drainage, and sewage water respectively. The pH was (7-7.3) and slight difference was observed in the temperature of the three habitats being 36.3°C; 35.1°C for the released water and sewage water respectively, drainage water had a markedly lower temperature (18.2°C). In the study period, total organic matter values (TOMC) was relatively higher in sewage water (25 ppm) compared to released (6 ppm) and drainage water (10 ppm). The value of chemical oxygen demand (COD) was relatively higher in drainage water (32 ppm) compared to released water (19 ppm) and sewage water (4ppm). On the other hand, the biological oxygen demand was relatively higher in sewage water (52 ppm) than released (18 ppm) and drainage ones (38 ppm). Released water was more saline (698.1 mg/L) than drainage (277.3 mg/L) and sewage water (198.4 mg/L).

Sewage water had significantly higher conc. of heavy metals compared to released (F=0.005; d. f. =5; P<0.001) and drainage water (F=0.002; d. f. = 5; P<0.001). Comparable metal concentrations were recorded in both released and drainage water (F= 3.9; P=0.07; Tab. 1). Iron conc. was higher than other metals in all habitats. But, concentrations of the remaining recorded metals were highly positively correlated where the values of the correlation coefficient (r) ranged from 0.8 to 0.9 (Tab. 4).

Table 2: Mosquito species diversity in three habitats

Water	*Cx. pipiens*	*Cx. pusillus*	*Cx. perexiguus*	*Cx. theleri*	*Oc. caspius*	*An. multicolor*	*An. pharoensis*
Release	2599	152	0	0	83	69	0
Drainage	3206	240	0	0	0	74	53
Sewage	4971	0	306	257	0	0	0
Total	10776	392	306	257	83	143	53

Table 3: Monthly abundance of mosquito species in habitats at Ismailia G., 2008

Water	Released				Agricultural drainage				Sewage		
Sp. / Month	*Cx. pipiens*	*An. multicolor*	*Cx. pusillus*	*Oc. caspius*	*Cx. pipiens*	*An. multicolor*	*Cx. pusillus*	*An. pharoensis*	*Cx. pipiens*	*Cx. perexiguus*	*Cx. theleri*
Jan	160	6	9	3	153	5	9	4	324	21	15
Feb	98	3	6	4	168	5	10	4	235	14	13
Mar.	138	4	7	4	161	4	11	3	347	22	17
April	197	5	11	6	307	9	21	5	508	30	27
May	205	6	13	7	301	8	22	4	548	34	27
June	216	6	12	7	304	8	24	5	553	33	29
Jul.	256	7	16	9	210	6	14	4	410	25	21
Aug.	337	9	19	10	331	6	26	5	442	28	24
Sept.	270	6	16	9	342	5	36	5	453	27	26
Oct.	252	6	16	7	368	7	21	5	420	28	19
Nov.	244	6	14	9	322	6	28	5	405	24	22
Dec.	226	5	13	8	239	5	18	4	326	20	17
Total	2599	69	152	83	3206	74	240	53	4971	306	257
%	89.5	2.4	5.2	2.9	89.7	2.1	6.7	1.5	89.8	5.5	4.6

Table 4: Person correlation coefficients (r) for correlation between heavy metals concentrations in water

Metal	Zn	Fe	Cd	Cu	Pb	Mn
Zn	1					
Fe	0.998493	1				
Cd	0.990604	0.996616	1			
Cu	0.891067	0.864818	0.820621	1		
Pb	0.997158	0.99979	0.998092	0.854338	1	
Mn	0.987453	0.994631	0.999771	0.808216	0.996544	1

Discussion

In the present study, highest densities of mosquito larvae were recorded in sewage water, the organically rich habitat. In contrast relatively lower densities were recorded in both drainage and released water bodies which were characterized by low organic matter content. The shading of drainage water by plants declined water temperature resulting in slow weed decomposition (Bambaradeniya and Amerasinghe, 2003) and reduction in algae growth which in turn reduced the availability of larval food (Al-Shami *et al*, 2009). Alternatively, the high water level in drainage canals may have also diluted the amount of organic matter and nutrients in general. Low population density of mosquito larvae in derange water could be also related to the toxic effect of certain chemical insecticide applied during the study period. Also, subjection of released water to weak light as a result of being surrounded by buildings caused reduction in plantation growth leading to low level of organic matter.

Many Egyptian reports (Mikhail *et al*, 2009, Kenawy, 1990, Kenawy *et al*, 1987, El Bahnasawy *et al*, 2013) found that *Cx. pipiens* was the commonest species. The present results proved that *Cx. pipiens* larvae survive at all the recorded pH values reached their maximum density peak at the neutral pH (7-7.3).

The concentrations (conc.) of heavy metals varied in the three habitats. The factors underlying these differences may be complex. Further studies are needed on the sources of pollutants, soil composition particularly the physical and chemical characteristics, precipitation patterns, and composition of flora growing in the study areas. Elevated levels of heavy metals observed in sewage water, underscores the anthropogenic nature of heavy metals pollution in the study areas. The positive correlations observed between the heavy metals concentrations in the three habitats suggested relative uniformity of the sources of metal pollutants (Onyri and Wandiga, 1989; Okoy *et al,* 1991; Mireji *et al*, 2008). The presence of significantly high densities of *Cx. pipiens* larvae under these elevated levels of heavy metals suggests their high tolerance to heavy metals in the three habitats particularly in sewage water. It may be also due to beneficial and compensatory effects of high nutrient levels associated with sewage or domestic waste present (Clements and Kifney, 1994; Reroldi *et al*, 1997). The aquatic insects chronically exposed to heavy metals were previously reported to exhibit increased tolerance relative to native population (Klerks and Weis, 1987; Krantzberg and Stoks, 1990; Hare, 1992; Pagliara and Stabili, 2012).

Previous studies demonstrated greater tolerance of culicines to elevated levels of heavy metals in different habitats (Linthicum, 2012). Though culicine larvae are greatly opportunistic and widely distributed in the three studies habitats, in contrast anophline larvae were only recorded in the relatively less polluted habitats with sand or mud substrates (released and drainage water). Previous studies showed that anophiline immature stages are generally thought to occur in clean sunlit habitats (Gillett, 1972; Chavasse *et al*, 1995; Service, 1995).

The decreased densities of anopheline larvae during the present study may also be related to co-existence with high densities of culicine larvae in the same habitats which could result in competitive interactions. Impoinvil *et al*. (2008) showed that the crowded habitat with one mosquito species might prevent other mosquito species from colonizing the habitats. Furthermore, different habitat characteristics impact the extent to which these mosquitoes encounter one another, hence influencing interspecific species interaction (Lloyd, 1995).

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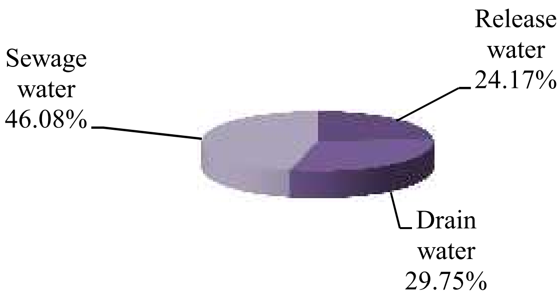

Figure 2: Larval abundance in three studied habits

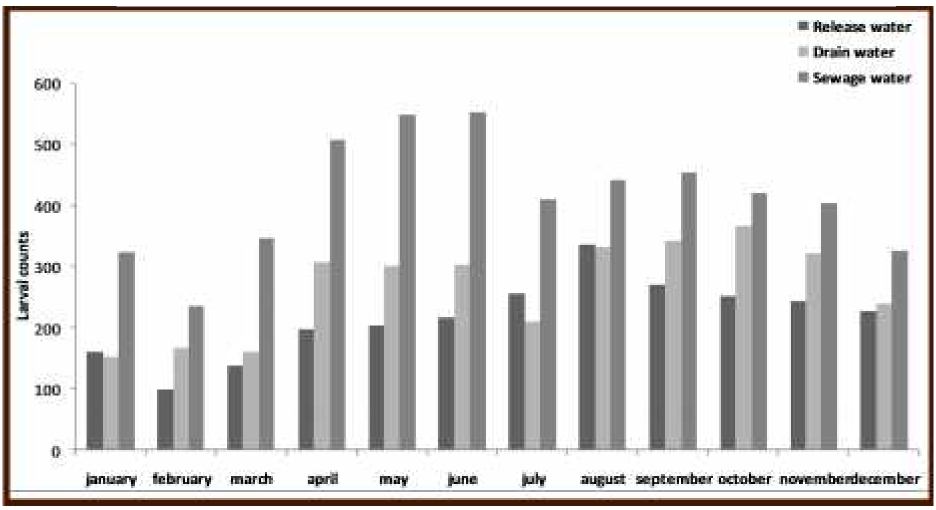

Figure 3: Abundance of *Culex pipiens* larvae in the 3 studied habitats.