Egypt. J. Vet. Sci. **Vol. 55,** No. 4, pp. 991-1006 (2024)

Egyptian Journal of Veterinary Sciences

https://ejvs.journals.ekb.eg/

Ecological Factors Affecting Diversity and Abundance of Mosquito Larvae in Nile Delta, Egypt

Mohamed M. Baz [1*], Rowida S. Baeshen [2], Nancy M. El-Shourbagy [1], Wafaa M. Hikal [2,3], Hanem F. Khater [4], Ahmed B. Darwish [5], Yasser A. El-Sayed [1] and Eman Abdelrahman Abououf [6]

[1] *Department of Entomology, Faculty of Science, Benha University, Benha 13518, Egypt.*

[2] *Department of Biology, Faculty of Sciences, Tabuk University, Tabuk, 71491, Saudi Arabia.*

[3] *Department of Water Pollution Research, Environmental Research Division, National Research Centre, Giza, Egypt.*

[4] *Department of Parasitology, Faculty of Veterinary Medicine, Benha University, Egypt.*

[5] *Zoology Department, Faculty of Science, Suez University, Suez, 43518 Egypt.*

[6] *Department of Parasitology, Faculty of Medicine, Benha University, Egypt.*

Mosquitoes are vectors for many pathogens that threaten human and animal health around the world. The present study investigated the correlation between the physicochemical parameters of the breeding habitats and the diversity and abundance of mosquitoes in two villages, Nile Delta, Egypt. A total of 258 breeding places were found positive for mosquito larvae including 46 (17.8%) pools, 41 (15.9%) irrigation basin, 36 (14.0%) drainage ditches, 28 (10.9%) unused wells, 27 (10.5%) irrigation ditches, 23 (8.9%) canals, 22 (8.5%) ground pits, 19 (7.4%) drainages, and 16 (6.2%) temporary pools in Barqata south the Delta Nile. a total of 370 breeding places were found positive for mosquito larvae including 48 (13.0%) rice fields, 46 (12.4%) unused wells, 44 (11.9%) drainage ditches, 40 (10.8%) sakia pits, 36 (9.7%) canals, 34 (9.2%) drainages, 25 (6.8%) pools, 24 (6.5%) swamps, 22 (5.9%) ground pits, 21 (5.7%) irrigation channel, 19 (5.1%) irrigation basin, and 11 (3.0%) temporary pools, respectively in El-Qantara village. Unused wells and pools (340.0 and 278.3 larvae/dip) were the most vital breeding habitats in Barqata village, while rice fields, drainages, and pools formed the largest sources of mosquito breeding in El-Qantara village and contained the highest density of mosquito larvae (619.2, 513.3 and 432.5 larvae/dip). The occurrence of *Culex pipiens* in polluted water indicates a real risk and the potential for disease transmission. Mosquito larval density was positively correlated with temperature, salinity, nitrate, and conductivity. The results indicated that unused wells and pools are a widespread and permanent source of breeding mosquitoes.

Keywords: Physicochemical; Mosquitoes; Abundance; Nile Delta.

Introduction

Mosquitoes are vectors for more pathogens that threaten human and animal health around the world than any other arthropod insect, such as malaria, filariasis, West Nile fever, yellow fever, and dengue fever [1, 2]. Mosquitoes spread wherever there are bodies of fresh water, and it prefers to live in warm, humid environments. It can lay eggs in any stagnant water, whether in a pond or any water collection [3]. Most mosquito species prefer to live in permanent, semi-permanent, or artificial natural breeding places and are related to the water quality and the surrounding environmental conditions that may affect the abundance and prosperity of mosquitoes. These breeding places are in both urban and rural areas, while the villages of El-Qantara in Kafr El-Sheikh Governorate, north of the Delta, and the village of Barqta in Qalyubiya Governorate, south of the Delta, and some rural areas distinguished with

*Corresponding author: Mohamed M. Baz, E-mail: mohamed.albaz@fsc.bu.edu.eg. Tel.:00201063070572
(Received 28/08/2023, accepted 24/12/2023)
DOI: 10.21608/EJVS.2023.232420.1581

plenty of vegetation cover, landscapes, and the diversity of water sources, in addition to the populated human density and animal diversity, make the El-Qantara and Barqata villages a permanent focus for the spread of mosquitoes with the possibility of transmitting diseases to humans and animals.

Some ecological factors such as water temperature, vegetation, pH, turbidity, ammonia, nitrates, and chloride concentrations can influence egg-laying and larval density [4,5]. Moreover, we find that some very important climatic factors, such as humidity, temperature, and wind speed [6,7].

Mosquitoes are attracted to and breed in various water habitats and are specific to some species due to their association with water quality, characteristics, and the nature of the place. Anopheles species breed in small, vegetation-rich, open, sunlit freshwater habitats, while *Culex* species breed in polluted water habitats such as ditches, cesspits, and open sewage systems [8]. Therefore, several researchers are interested in studying the ecological factors that affect mosquito larval biology, such as the physicochemical properties of the water, interspecific associations, biodiversity, attraction, association indices of disease vectors, and spatial-temporal distribution, and thus understanding these parameters is important for establishing suitable mosquito control programs [9].

The diversity of mosquito breeding sites and their characteristics still inspire and confuse researchers in determining which physiological factors are most influential, specifically in the abundance of mosquito larvae in the water containers [1,10,11].

There is a need for more studies on documenting the relationship between physical and chemical properties and which of them is an indicator of the presence or absence of mosquito larvae species or density in their habitats. The goal of this study was to find out if there was a correlation between the physicochemical parameters of the breeding habitats and the variety and number of immature mosquitoes in El-Qantara village in Kafr El-Sheikh Governorate north of the Delta and Barqta village in Qalyubiya Governorate south of the Delta as a model for rural villages in the Nile Delta, North Egypt.

Material and methods

Study area

Barqata village located in the center of Kafr Shukr (30°29'20.64"N 31°15'56.68"E), Qalyubiya Governorate, 65 km to the northeast of Cairo (Fig. 1).

Fig. 1. Study area location of Kafr El-Sheikh and Qalyubiya areas of the Nile Delta (modified after Negm [14])

There are many water sources such as canals, unused wells (Sakia pits), and ditches that are branching through the populated area that usually contain stagnant and polluted water around the homes. There are many pools and unused wells that exist in some areas within the village and have water for a longer period Furthermore, some villagers are throwing the home garbage in the water. Most of the residents are illiterate farmers and the main crops grown are citrus trees, corn, and vegetables (Fig. 2). El-Qantara village is located three km north of Kafr El-Sheikh town (31°06′42″N 30°56′45″E), and 134 km north of Cairo, in the Nile Delta of lower Egypt. The village is an urbanized, densely populated area provided with a sanitation system. There are many water bodies, including rice fields, swimming pools, old unused wells (Sakia pits), markets, and permanent irrigation channels that exist in some areas within the village, and water is available for a longer period. The houses are used for residence and rarely for raising domestic animals. The main cultivated crops are rice, wheat, maize, clover, palm plantations, and vegetables (Fig. 3).

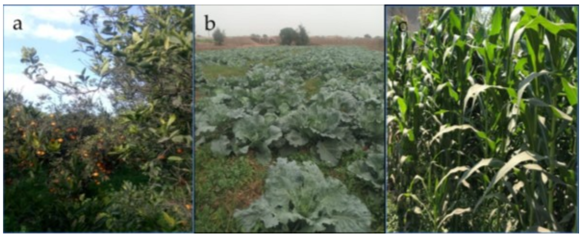


Fig. 2. The main crops in Barqata village (Qalyubiya Gov.): Citrus trees (a), Cabbage (b) and Corn plants (c).

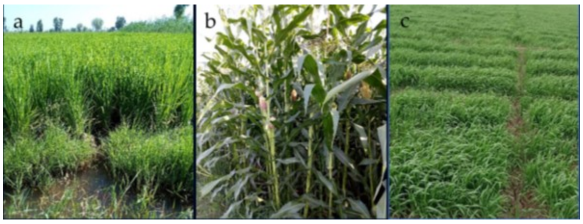


Fig. 3. The main crops in El-Qantara village (Kafr El-Sheikh Gov.): Rice (a), Corn (b), and Wheat plants (c).

Mosquito breeding places

All water collections were surveyed for the presence of mosquitoes and categorized according to that of [12] as follows; irrigation basins, pools (semi-permanent), drainage ditches (small), irrigation ditches, temporary pools, ground pits (temporary), and, unused wells, drainages (big), and canals. Drainage ditches are small ditches (1.5 meters wide) located between agricultural lands, while drainages are large channels in width and length and are often located on the borders of a residential or agricultural block. Mosquito breeding places were surveyed bi-weekly from August 2020 to January 2021.

Sampling of mosquito larvae

Mosquito larvae were collected from stagnant water collections in various places in Barqata and El-Qantara villages. Three dips were taken from each breeding site using a stander dipper (450 ml). Larval densities were calculated as the average number of larvae/dips collected from each habitat. Collected larvae were transported to the laboratory for identification according to the keys of [13].

Water quality

Some physical and chemical parameters, such as water temperature (°C), acidity (pH), dissolved oxygen (ppm), salinity (ppm), nitrates (mg/l), and electrical conductivity (µs/cm) were measured using a thermometer, a pH probe (PH5500), portable DO, TDS meters, a spectrophotometer device (UV/Visible Lambda EZ201), and a conductometer device (EC LYTIC-AQUA), respectively. Water samples (500 ml) were placed in labeled polyethylene containers kept in an icebox from all aquatic mosquito breeding sites (9 in Barqata village and 12 in El-Qantara village) at the Central Laboratory for Water Quality Analysis, Faculty of Agriculture, Benha University, Egypt.

Statistical analysis

The Statistical analyses were carried out using ANOVA with five factors under the significance level of 0.05 for the results using SPSS (ver. 23). Data were treated as a complete randomization design according to [15]. Multiple comparisons were carried out applying LSD. Multiple regressions were analyzed using Canonical Correspondence Analysis (CCA) to determine the relationships between the physicochemical parameters of breeding places and the density of mosquitoes.

Results

Mosquito breeding places and density of mosquito larvae

A total of 258 breeding places were found positive for mosquito larvae including 46 (17.8%) pools, 41 (15.9%) irrigation basin, 36 (14.0%) drainage ditches, 28 (10.9%) unused wells, 27 (10.5%) irrigation ditches, 23 (8.9%) canals, 22 (8.5%) ground pits, 19 (7.4%) drainages, and 16 (6.2%) temporary pools in Barqata south the Delta Nile (Table 1, Fig. 4). While at El-Qantara village north the Delta Nile, a total of 370 breeding places were found positive for mosquito larvae including 48 (13.0%) rice fields, 46 (12.4%) unused wells, 44 (11.9%) drainage ditches, 40 (10.8%) sakia pits, 36

(9.7%) canals, 34 (9.2%) drainages, 25 (6.8%) pools, 24 (6.5%) swamps, 22 (5.9%) ground pits, 21 (5.7%) irrigation channel, 19 (5.1%) irrigation basin, and 11 (3.0%) temporary pools (Table 2, Fig. 5).

The data given in Table 1 and Fig. 6a (r^2= 0.5776; F= 36.014; P= 0.001) revealed that unused wells and pools were the most vital breeding habitats in Barqata village. The mean number of collected larvae was 340 and 278.3 (23.9 and 19.6%), respectively, followed by drainages 229.0 (16.1%), drainage ditches 176.0 (12.4%), canals 128.3 (9.1%), ground pits 93.5 (6.6%), irrigation ditches 88.7 (6.2%), and irrigation basins 55.0 (3.9%); whereas temporary pools had a very low density of larvae (31.0 (2.2%) in Barqata village.

Similar to the response, the results of this work showed that rice fields and drainage (r^2= 0.5776; F= 36.014; P= 0.001) were the most vital breeding habitats in El-Qantara village (Table 2 and Fig. 6b). The mean number of collected larvae was 614.2 and 513.3 (16.7 and 14.0%), respectively, followed by pools 432.5 (11.8%), unused wells 426.7 (11.5%), drainage ditches 359.2 (9.8%), sakia pits 313.3 (8.5%), swamps 271.7 (7.4%), canals 211.3 (5.8%), ground pits 200.3 (5.5%), irrigation channels 180.0 (4.9%), and irrigation basins 99.2 (2.7%); whereas temporary pools had a very low density of larvae 51.7 (1.4%) in El-Qantara village. where a, b, and c symbols mean that there is no significant difference (P>0.05) between any two means, within the same column having the same superscript letter. Besides, A, B, and C symbols mean that there is no significant difference (P>0.05) between any two means for the same attribute, within the same row having the same superscript letter.

TABLE 1. Mosquito larval habitats and mean the number of larvae collected from nine breeding sites in Barqata village, Qalyubiya Governorate.

No.	Breeding place	No. of +ve breeding site (%)[1]	Mean ±SD[2]	(%)	F value	Significant (P)
1	Unused well	28 (10.9)	340±31.68^{a}	23.9		
2	Pool	46 (17.8)	278.3±15.85^{a}	19.6		
3	Drainage	19 (7.4)	229.1±12.28^{b}	16.1		
4	Drainage ditch	36 (14.0)	176.0±13.65^{d}	12.4		
5	Canal	23 (8.9)	128.3±15.67^{e}	**9.1**	49.25	0.0001
6	Ground pit	22 (8.5)	93.5±6.77^{ef}	6.6		
7	Irrigation ditch	27 (10.5)	88.7±7.96^{f}	6.2		
8	Irrigation basin	41 (15.9)	55.0±6.44^{fg}	3.9		
9	Temporary pool	16 (6.2)	31.0±7.61^{g}	2.2		

a, b & c: There is no significant difference (P>0.05) between any two means, within the same column that have the same superscript letter. [1] %: (No of the site/No. all sites), [2] Density: (No of larvae/dip).

TABLE 2. Mosquito larval habitats and mean the number of larvae collected from nine breeding sites in El-Qantara village, Kafr El-Sheikh Governorate.

No.	Breeding place	No. of +ve breeding site (%)[1]	Mean ±SD[2]	(%)	F value	Significant (P)
1	Rice field	48 (13.0)	614.2±43.46^{a}	16.7		
2	Drainage	34 (9.2)	513.3±32.03^{ab}	14.0		
3	Pool	25 (6.8)	432.5±18.08^{c}	11.8		
4	Unused well	46 (12.4)	426.7±38.01^{c}	**11.5**		
5	Drainage ditch	44 (11.9)	359.2±37.63^{cd}	9.8		
6	Sakia pit	40 (10.8)	313.3±27.83^{de}	8.5		
7	Swamp	24 (6.5)	271.7±44.02^{ef}	7.4	26.71	0.0001
8	Canal	36 (9.7)	211.3±12.87^{ef}	5.8		
9	Ground pit	22 (5.9)	200.3±27.87^{fg}	5.5		
10	Irrigation channel	21 (5.7)	180.0±24.44^{gh}	4.9		
11	Irrigation basin	19 (5.1)	99.2±8.93^{hi}	2.7		
12	Temporary pool	11 (3.0)	51.7±13.0i	1.4		

a, b & c: There is no significant difference (P>0.05) between any two means, within the same column that have the same superscript letter1. %: (No of the site/No. all sites), [2] Density: (No of larvae/dip).

Fig. 4. Mosquito larval breeding places in Barqata village. Irrigation basin (A), Pool (B), Drainage ditch (C), Irrigation ditch (D), Temporary pool (E), Ground pit (F), Unused well (G), Canal (H), Drainage (I).

Fig. 5. Mosquito larval breeding places in El-Qantara village. Canal (a), drainage (b), swamp (c), unused well (d), rice field (e), irrigation channel (f), sakia pit (g), pool (h), ground pit (i), irrigation basin (j), temporary pool (k), drainage ditch (l).

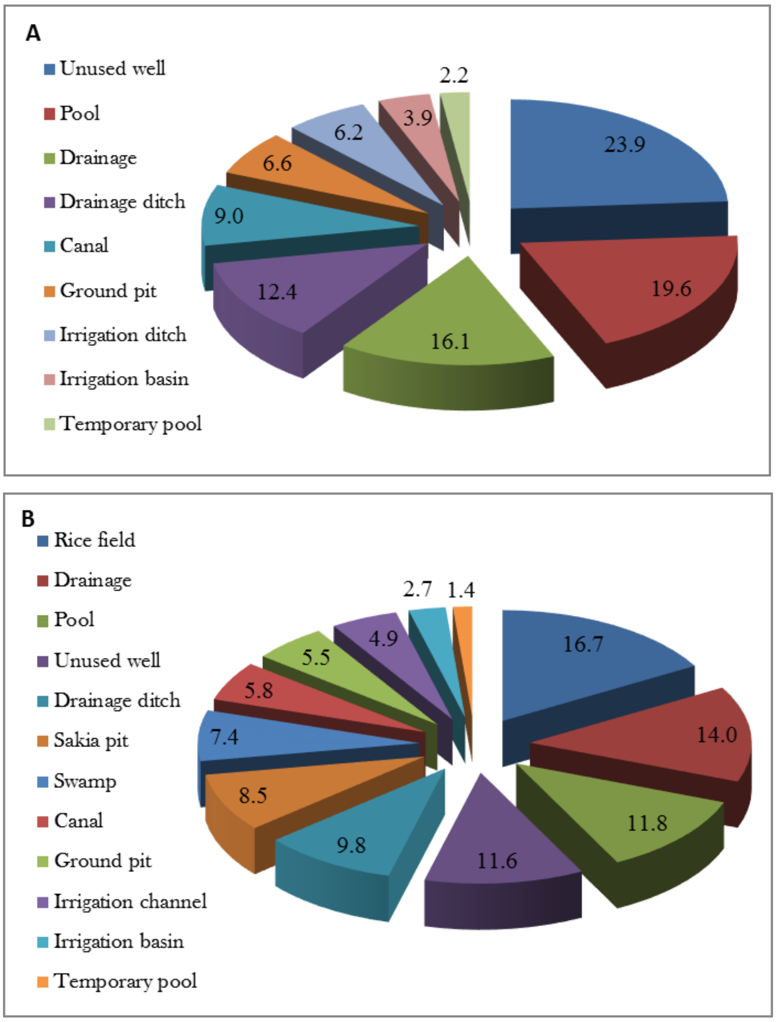


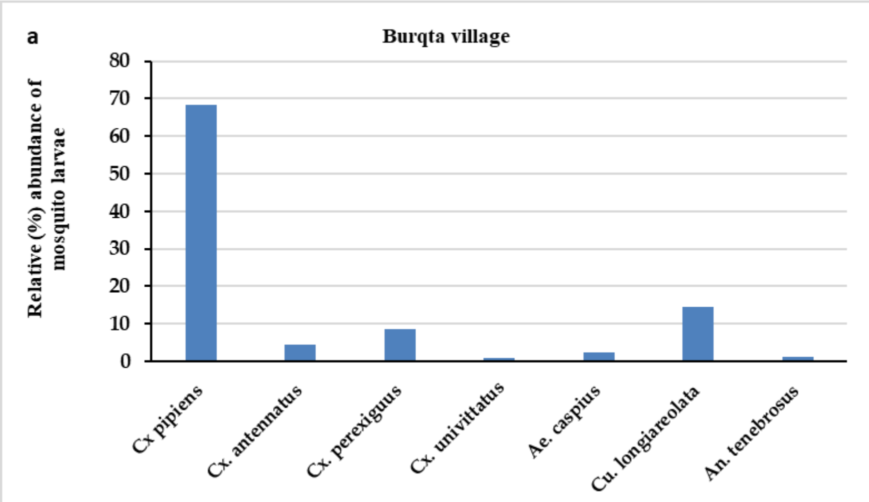
Fig. 6. Relative density (%) of mosquito larvae collected at breeding habitats in Barqata (a) and El-Qantara (b) villages.

The relative abundance of mosquito larvae

A total of 8520 larvae of seven species were collected from nine different breeding sites, of which *Culex pipiens* (68.2%), *Culliseta longiareolata* (14.4%), and *Cx. perexiguus* (8.5%) were the most common species, whereas *Anopheles tenebrosus* (1.1%) and *Cx. univittatus* (0.8%) were uncommon in Barqata village (Fig. 7a). Also, data showed that ten species (22040 larvae) were collected from 12 different breeding sites, of which *Cx. antennatus* (25.4%) and *Culex pipiens* (21.5%), were the most common species, while *An. multicolor* (2.5%) was uncommon in El-Qantara village (Fig. 7b).

The physicochemical characterization

The physicochemical parameters of breeding places inspected in the present study are summarized in Tables 3-6. In Barqata village, the results showed that water temperatures were close in all mosquito-breeding places, but it was relatively high in unused wells (25 °C) and pools (24.5 °C). The values of pH and dissolved Oxygen were moderate in slow-moving water streams as in canals (8.5 pH and 10.8 D.O), and irrigation ditches (8.1 pH and 10.1 D.O), where the mean value was 7.5 pH and 8.7 ppm, respectively for all breeding sites. A high level of nitrate was observed in most mosquito breeding places, but it was the highest in drainages (1.40 mg/l) followed by unused wells (1.01 mg/l), pools (0.95 mg/l), and drainage ditches (0.88 mg/l). In addition, drainages, unused wells, and pools recorded the highest levels of conductivity (1186.6, 987.5, 911.7 µS/cm), and salinity (1038.3, 864, 769.3 ppm), respectively. In the village of El-Qantara, the results showed that water temperatures were variable in some mosquito breeding sites but relatively high in unused rice fields (28.5 °C) and pools (27.5°C).



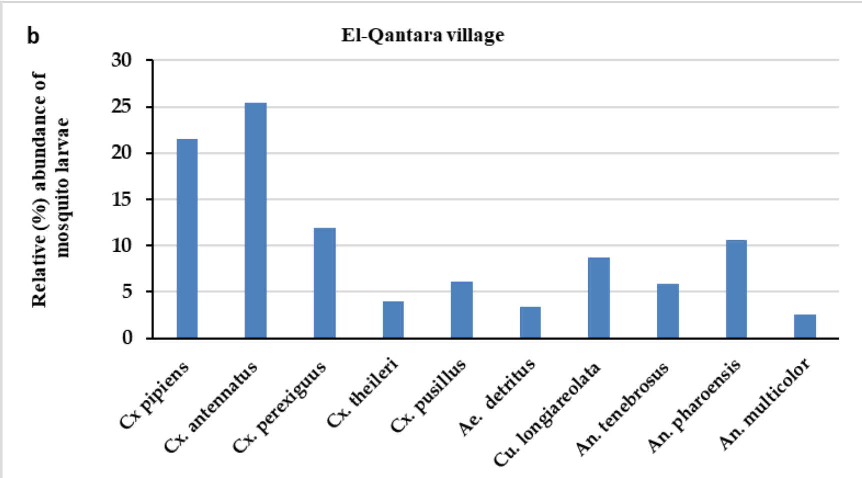


Fig. 7. Relative (%) abundance of mosquito spices in Barqata (a) and El-Qantara (b) villages

Physicochemical and Mosquito prevalence

(i) Barqata village: The association between mosquito larvae species collected and the physicochemical parameters of breeding water is presented in Tables 5. *Culex pipiens* and *Cx. perexiguus* observed in water with low temperature (14 °C). *Culex pipiens* had also a relative tolerance to high temperatures (32 °C). *Anopheles tenebrosus* tends to prefer high dissolved oxygen (7.5-13.6 ppm) and relatively high alkalinity (7.3-9.8 pH). *Culex pipiens* tolerated a high salinity range. *Culex perexiguus, Cx. pipiens,* and *Culiseta* longiareolata breed in polluted high nitrate (0.46-1.32, 0.6-1.5, 0.6-1.2 mg/l) and conductivity (380-1780 ms/cm) while *Cx. antennatus* and *An. tenebrosus* breed in water free of nitrate.

(ii) El-Qantara (b) village: Data presented in Table 6 showed that *Cx. antennatus, Cx. perexiguus,* and *Anopheles* species were observed in water with a moderate temperature (14 to 28 °C), while *Cx. pipiens* was also relatively tolerant of high temperatures (32 °C). Most mosquito species were collected in sites with high Dissolved oxygen, whereas *Anopheles tenebrosus, An. pharoensis, An. multicolor, Cx. antennatus,* and *Cx. perexiguus* tend to prefer high dissolved oxygen (6.8–13.4 ppm) and relatively high alkalinity (7.1–11.4 pH). Most of the *Culex* species recorded—*Culex perexiguus, Cx. pipiens, Culiseta longiareolata, Cx. perexiguus, Cx. theileri,* and *Cx. pusillus* reproduce in high nitrate concentrations (1.55, 1.35, 1.14, and 1.12 mg/L) and conductivity (423–1785 msec/cm), while *Cx. antennatus* and *An. tenebrosus* breed in nitrate-free water. The water quality provides a clear picture of the general state of the water, as the density of mosquito larvae was positively related to temperature (r2 = 0.7650), salinity (r^2 = 0.6063), nitrate (r^2 = 0.7311), and conductivity (r^2 = 0.7115), while there was no correlation found between the density of mosquito larvae and water pH and dissolved oxygen (r^2 = -0.4614 and -0.5546), respectively (Table 6).

Multiple regression analysis showed that the regression model was significant (adjusted R^2 = 0.8928; F = 4.789; P = 0.2336). According to the developed model, only temperature, nitrate, and conductivity can be used as predictor variables for mosquito larvae density (β = 7.63; P = 0.0002), (β = 7.84; P = 0.0001), and (β = 7.71; P = 0.0065), respectively.

Discussion

The Egyptian Nile Delta governorates have a lot of greenery and fresh water sources. In Kafr El-Sheikh and Qalyubiya Governorates, for example, there are several aquatic mosquito habitats that are permanent, semi-permanent, or temporary places for mosquitoes to breed and reproduce.

This study looked at the relationship between the physicochemical parameters of mosquito breeding habitats and the variety and number of mosquito immatures in Barqata village (Qalyubiya Governorate), and El-Qantara village (Kafr El-Sheikh Governorate), as a model for rural villages in the Nile Delta. The goal was to get accurate data that could be used to control mosquitoes in the right way or to designing appropriate strategies for mosquito control. According to the results indicated in Barqata village, unused wells and pools are a widespread and permanent source of breeding with high productivity for mosquitoes (340.0 and 278.3 larvae/dip, respectively). Also, our data showed that in the village of El-Qantara, rice fields, drainages, pools, and unused wells are permanent breeding grounds for a lot of mosquitoes (619.2, 513.3, 432.5, and 426.7 larvae/dip, respectively), where the rice fields are seasonal cultivation (semi-permanent). Moreover, temperature, nitrate, and conductivity could be used as predictor variables for mosquito larvae density. Therefore, our findings provide accurate and reliable data for appropriate mosquito control in the future.

Unused wells were used for irrigation in the past in most Egyptian villages, but most of them have been neglected at present. The high density of mosquitoes in unused wells may be due to the nature of underground water, the presence of different types of suspended materials such as aquatic plants, mud, garbage, or decomposing foods, and/or the protection provided to larvae against fluctuation in environmental conditions. Therefore, it is considered one of the most vital habitats for mosquito breeding in many areas of the Qalyubiya and Kafr El-Sheikh Governorates [4, 17]. Pools were the second largest positive breeding sites in Barqata village 46 (17.8%), where the mosquito density was 278.3 (19.6%) larvae/dip, and they were in the third position of positive breeding sites in El-Qantara village 25 (6.8%), where the mosquito density reached 432.5 (11.8%) larvae/dip. The results of the study agree with many of the authors, including [3,16,18].

Pools are usually neglected and filled with many materials, like vegetation, debris, and human waste. This site is depressing (a pit) or low ground filled with water from flooding irrigated lands or damage to canal banks [17]. Parallel to this work, we found that in El-Qantara village, the rice fields and the drainages contained a high positive percentage of mosquito habitats and a high density of mosquitoes.

Rice fields are widely spread across agricultural lands in the northern Nile Delta, especially in Kafr El-Sheikh Governorate, and serve as seasonal breeding grounds. In the summer, rice is planted, and the rice water contains many types of mosquito larvae at different stages of plant growth. The rice fields are characterized by open horizontal water bodies with an abundance of nutrients and stagnant water. In general, there is little information available on the surface water quality of rice paddy larvae habitats in Kafr El-Sheikh [18,19]. Therefore, due to its short lifespan and irrigation system, there has been a significant rise in mosquito diversity, abundance, and the rate at which mosquito-borne diseases like filariasis are transmitted [18].

Drainages (agricultural drains) are the largest breeding sites found in the study areas, where the density of mosquito larvae was higher in El-Qantara village (513.3 larvae/dip) than in the Barqata village (229.1 larvae/dip). This type of breeding site was usually filled with decaying materials like vegetation, debris, and human waste. It plays an important role in the spread of mosquitoes and the sustainability of water throughout the year.

Most of the breeding sites were encountered as a permanent site that held water throughout the whole year as in unused wells, canals, drainages, while some habitats were temporary that contain water for several weeks or a short period according to the Egyptian farming system as in case of rice fields or the activity of villagers such as water pits and drains. The high abundance of mosquito larvae in unused wells was also observed in Qalyubiya Governorate by many investigators [3,16].

Our observations come along with the other's observations [1,17,20]. Mosquitoes usually inhabit and breed in a wide range of differentiated water containers, but the high abundance of mosquito larvae, thrive, and grow were noted in small water containers that characterized by standing water with some weeds or plants away from running water such as pools, unused wells, catch basins and drainages that contain the highest density of mosquito larvae [21]. It appears that these sites played a major role in mosquito abundance in Kafr El-Sheikh and Qalyubiya Governorates, Egypt.

Our results highlight the role of these places as real foci of breeding and spread of mosquitoes, so we need mosquito control in these places to reduce the possibility of transmitting and spreading diseases to the residents of the village [3,16]. Furthermore, our observations showed that almost all permanent habitats had stagnant or slow-moving water and vegetation, organic debris from dead organisms, or decaying plants were often important sources of nutrients to mosquito larvae. The debris was very high in unused wells, drainages, and pools [16,17].

Seven mosquito species were reported from Barqata village of which *Culex pipiens* (68.2%), was the most prevalence species, whereas ten mosquito species were reported from El-Qantara village and *Cx. antennatus* (25.4%) were the most common species. Most of the observed species reported in this study were previously encountered in other Nile Delta governorates [16,22-25].

The dominance of *Cx. pipiens*, which is known as the main vector of filariasis in Egypt, regarding density and/or distribution may indicate the suitability of available breeding sites to the breeding of this species and/or the ability of this species to live in a wide range of water sources. The high abundance and distribution of *Cx. pipiens* were also recorded by many other investigators [4,17,26-28]. Mosquito females try to choose suitable breeding grounds, and these sites are selected accordingly to their preferred characteristics that may help them to survive and for their population dynamics [17]. Many physical and chemical factors could attractant or deter mosquito oviposition sites. Certain conditions of the breeding site can be favored by most species, while other species may not [29].

The larvae of *Anopheles tenebrosus, An. pharoensis,* and *An. multicolor* were prevalence in the village of Qantara, north of the Nile Delta, while one species (*An. tenebrosus*) was collected in the village of Barqata, south of the Nile Delta. The abundance of *Anopheles* mosquitoes in the Nile Delta governorates, especially in the north, may be due to the diversity and expansion of green spaces, including rice fields, in addition to the quality of fresh water [28].

Anopheles pharoensis is the proven malaria vector, *An. multicolor* is suspected to be a vector, and *An. tenebrosus* has no role in malaria transmission [30], among other diseases. Culicine mosquitoes are vectors of filariasis [32], Rift valley fever virus [33], West Nile virus [34], and several other viruses [35].

Our data revealed that the physicochemical characteristics of the water habitats in Qalyubiya and Kafr El-Sheikh have a variable effect on mosquito larval breeding from one habitat to the next, where temperature, nitrate, and conductivity of the water are significantly different ($P > 0.05$).

In general, an increase in water temperature will result in faster development of aquatic stages but will reduce the size of emerging adults [27,36]. According to the WHO [37], most mosquito species may develop best in temperatures between 25 and 27 °C. For the recorded described species, a temperature range of 15–29 °C was found in the current study. Reported temperatures in other regions of Egypt ranged from 19 to 34 °C [22,38].

Our results are parallel to those of Jemal and Al-Thukair [39] who pointed out that the appropriate range for the production and survival of *Culex, Aedes,* and *Anopheles* larvae was between 16.4 - 27.7 °C in the eastern region of Saudi Arabia, while the average temperature in this region in the summer season reached greater than 35 °C, which turned out to be not suitable for larval growth.

Our results showed that mosquito larvae can live in relatively alkaline water (7.5 pH) in both villages, and this is what was shown by [38], who explained that mosquitoes breed in alkaline water (> 7) in several Egyptian Governorates. Densities of *Culex* species are directly related to temperature, pH, and nitrate content, while *Cs. longiareolata* (7.7–7.8) was found to be alkaline, *Cx. pusillus* (5.0–5.5) may have been acidophilic due to the nature of its breeding sites (cesspits and cesspools) [27].

Nutrition and temperature are the main factors that influence the growth and development of mosquito larvae. Some studies revealed a significant positive correlation between the density of *Cx. pipiens* larvae, and nitrate, alkalinity, electrical conductivity, and total hardness, while a negative correlation was observed between physiochemical agents and larval density [9, 40,41]. The findings and their implications should be discussed in the broadest context possible. Future research directions may also be highlighted.

In addition to these factors, some studies have shown that several chemical properties of the larval habitat in the peridomestic area are related to vegetation as well as different content of physicochemical characteristics, which may affect larval development and survival [42]. Some studies showed that corn cultivation contributes to the spread of malaria mosquitoes and exacerbates malaria transmission in sub-Saharan Africa [43,44].

The current and previous studies address multiple mechanisms to combat mosquitoes, such as the use of plant extracts, synthetic pesticides, and the treatment of traps and mosquito nets [45,46]. In addition, studying environmental and climatic factors is an influential factor in building an appropriate strategy to combat mosquitoes.

Conclusions

The present study investigated the correlation between physicochemical parameters of the breeding habitats and the diversity & abundance of immature mosquitoes in Barqata village, Qalyubiya Governorate, Egypt. The results indicated that unused wells and pools are a widespread and permanent source of breeding with high productivity for mosquitoes and rice fields as semi-permanent habitats that inhabit many mosquito species; moreover, temperature, nitrate, and conductivity could be used as a predictor variable for mosquito larvae density. Therefore, our findings provided reliable accurate data for appropriate mosquito control in the future.

Author Contributions: MMB, YAE, RSB, GAR, AAI, HFK and WMH were actively involved in idea imaging and work designing and execution. MMB, YAE, NME and GAR were carried out the methodology. MMB, AAI, RSB, WMH, and HFK were involved in data analysis, interpretation, and write-up of the manuscript. MMB, RSB and WMH have involved the analysis of water quality measurements. All authors MMB, AAI, YAE, RSB, GAR, NME, HFK and WMH approved the manuscript.

Author statement: This manuscript or a very similar manuscript has not been published, nor is under consideration by any other journal.

Conflicts of Interest: The authors declare that there is no conflict of interest.

Funding: This research received no external funding

Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Benha University, and approved by Ethics Committee of Faculty of Science, Benha University (Code No. BUFS 2023-18Ent).

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable

TABLE 3. Physicochemical characteristics of the breeding water in Barqata village, Qalyubiya Governorate during study period*

Parameter	Average value of physicochemical parameters									
	Un. well	**Pool**	**Drainage**	**Dr. ditch**	**Canal**	**Ground pit**	**Ir. ditch**	**Ir. basin**	**Temp. pool**	**Mean**
Temp. (°C)	26.0 ±1.9	26.5 ±2.2	25 ±2.1	23.5 ±2.0	22.5 ±1.8	22.5 ±1.8	22.0 ±1.8	22.4 ±1.7	21.5 ±2.3	23.5 ±0.5
pH	7.2 ±0.16	6.6 ±0.1	6.2 ±0.1	6.9 ±0.2	8.4 ±0.3	7.0 ±0.2	7.6 ±0.13	7.2 ±0.2	6.0 ±0.2	7.01 ±0.21
Dissolved O_2 (ppm)	7.9 ±0.23	7.7 ±0.3	6.95 ±0.3	7.8 ±0.3	10.8 ±0.6	7.9 ±0.1	10.1 ±0.6	8.5 ±0.3	7.6 ±0.2	8.4 ±0.42
Salinity (ppm)	864.0 ±92.3	769.5 ±56.7	1038.0 ±90.8	816 ±105.8	434.2 ±41.6	788.6 ±44.57	476.7 ±34.1	701.1 ±47.8	653.3 ±20.0	726.8 ±62.8
Nitrate (mg/l)	1.01 ±0.1	0.95 ±0.1	1.40 ±0.2	0.88 ±0.1	0.75 ±0.1	0.73 ±.01	0.51 ±0.1	0.77 ±0.01	0.44 ±0.1	0.80 ±0.10
Conductivity (µs/cm)	987.5 ±102.0	911.7 ±61.6	1186.6 ±52.3	831.7 ±76.0	586 ±33.4	764.2 ±22.5	616.8 ±62.2	778.7 ±50.2	560.0 ±22.8	802.6 ±68.4

Un. well: Unused well; Dr. ditch: Drainage ditch; Ir. ditch: Irrigation ditch; Ir. basin: Irrigation basin; Temp.: Temporary pool.

TABLE 4. Association between mosquito species collected and their physicochemical parameters of breeding water at Barqata village, Qalyubiya Governorate

Parameter	Mosquito species and range of physicochemical parameters										Co. *	Multiple regression	
	Range (Min-max)	Stander [1] range	Description [1]	*Cx. pipiens*	*Cx. antennatus*	*Cx. perexiguus*	*Cx. univittatus*	*Ae. caspius*	*Cu. longiareolata*	*An. tenebrosus*	(r^2)	β	P
Temp. (°C)	15.6 30.4	< 30 ≥ 30	Normal temp. Hot	14 34	18 31	14 30	14 29	15 29	16 32	18 28	0.9255	8.32	0.0001
pH	5.6 8.7	7 7-11	Neutral Weak basic	4.5 9.2	6.2 9.4	5.6 8.8	5.6 9.3	4.1 6.9	5.6 7.5	7.3 9.8	-0.4621	-15.92	0.3391
Dissolved O_2 (ppm)	6.2 10.9	< 8 ≥ 14	Freshwater Polluted water	5.6 10.5	7.1 11.5	7.0 11.8	7.0 12.4	4.8 8.1	4.2 9.1	7.5 12.6	-0.3320	-19.79	0.3822
Salinity (ppm)	430 1253	< 500 ≥ 500	Freshwater Polluted water	480 1640	390 1100	440 1050	310 850	560 1780	490 1490	340 860	0.5510	-60.54	0.1240
Nitrate (mg/l)	0.5 1.1	< 0.5 ≥ 0.5	Freshwater Polluted water	0.6 1.5	0.39 0.88	0.46 1.32	0.34 0.98	0.44 0.89	0.6 1.4	0.41 0.63	0.7163	5.80	0.0300
Conductivity (µs/cm)	502 1402	< 800 ≥ 800	Domestic water Polluted water	750 1710	220 975	650 1660	550 1560	675 1520	460 1640	210 750	0.7471	7.11	0.0215

[1] Based upon [14]; N.B: F value = 4.789; P= 0.2336; and R^2= 0.8928; Co: Correlation

TABLE 5. Physicochemical characteristics of the breeding water in El-Qantara village, Kafr El-Sheikh Governorate during study period*

Parameter	Average value of physicochemical parameters												
	Rice field	Drainage	Pool	Un. well	Dr. ditch	Sakia pit	Swamp	Canal	Ground pit	Ir. channel	Ir. basin	Temp. pool	Mean
Temp. (°C)	29.5 ±2.2	27.0 ±2.1	27.5 ±2.2	26.0 ±1.9	25.5 ±2.0	24.0 ±1.8	25.0 ±1.8	24.0 ±1.8	22.5 ±1.8	23.0 ±1.8	23.0 ±1.7	23.0 ±2.3	25.0 ±0.8
pH	7.1 ±0.1	6.4 ±0.1	6.9 ±0.1	7.5 ±0.16	7.2 ±0.2	8.5 ±0.3	8.2 ±0.3	8.6 ±0.3	7.3 ±0.2	8.3 ±0.13	7.5 ±0.2	7.0 ±0.2	7.54 ±0.2
Dissolved O_2 (ppm)	9.6 ±0.3	7.9 ±0.3	7.6 ±0.3	8.5 ±0.23	7.8 ±0.3	11.6 ±0.6	10.6 ±0.6	12.4 ±0.6	7.9 ±0.1	10.0 ±0.6	8.7 ±0.3	7.7 ±0.2	9.2 ±0.55
Salinity (ppm)	718.3 ±56.1	995 ±90.8	715.3 ±16.7	664.0 ±92	756 ±105.8	534.2 ±41.6	484.2 ±42.0	422.2 ±41.3	735.6 ±44.5	416.7 ±34.1	695.1 ±42.8	666.3 ±20.0	650.2 ±5.3
Nitrate (mg/l)	1.13 ±0.1	1.40 ±0.2	0.96 ±0.1	1.21 ±0.1	1.12 ±0.1	0.78 ±0.1	0.69 ±0.1	0.59 ±0.1	0.75 ±.01	0.58 ±0.1	0.72 ±0.01	0.45 ±0.1	0.90 ±0.0
Conductivity (µs/cm)	918.5 ±61.6	1112. 0±52	910.2 ±61.6	889.5 ±79	851.1 ±76.0	582 ±33.4	551 ±33.4	686 ±33.4	755.2 ±0.23	611.6 ±62.2	798.7 ±50.2	512.0 ±22.8	764.8 ±52.4

Un. well: Unused well; Dr. ditch: Drainage ditch; Ir. ditch: Irrigation ditch; Ir. basin: Irrigation basin; Temp.: Temporary pool.

TABLE 6. Association between mosquito species collected and their physicochemical parameters of breeding water at El-Qantara village, Kafr El-Sheikh Governorate

Parameter	Mosquito species and range of physicochemical parameters													Co. *	Multiple regression	
	Range (Min-max)	Stander[1] range	Description[1]	*Cx. pipiens*	*Cx. antennatus*	*Cx. perexiguus*	*Cx. theileri*	*Cx. pusillus*	*Ae. caspius*	*Cu. longiareolata*	*An. tenebrosus*	*An. pharoensis*	*An. multicolor*	(r^2)	β	P
Temperature (°C)	15 31.1	< 30 ≥ 30	Normal temp. Hot	14 34	16 34	15 32	14 30	15 30	15 29	15 30	15 32	16 31	15 29	0.7650	7.63	0.0002
pH	6.0 9.9	7 7-11	Neutral Weak basic	5.5 9.8	6.8 10.4	5.6 9.8	5.6 9.8	4.8 9.8	4.1 6.7	5.8 7.8	7.3 12.2	7.4 11.4	7.1 10.8	-0.3514	-11.52	0.1832
Dissolved O_2 (ppm)	6.8 12.2	< 8 ≥ 14	Freshwater Polluted water	5.9 10.8	7.8 14.8	7.8 12.4	7.8 11.8	7.8 11.6	4.2 8.1	4.6 9.5	6.8 13.4	7.4 14.10	7.5 15.4	-0.5546	-15.19	0.3540
Salinity (ppm)	394 1102.5	< 500 ≥ 500	Freshwater Polluted water	420 1650	350 950	400 880	400 935	380 945	510 1680	420 1350	330 960	370 830	360 845	0.6063	-30.15	0.1110
Nitrate (mg/l)	0.42 0.98	< 0.50 ≥ 0.50	Freshwater Polluted water	0.5 1.40	0.36 0.74	0.42 1.14	0.38 1.12	0.42 1.12	0.44 0.80	0.5 1.35	0.36 0.78	0.36 0.68	0.41 0.71	0.7311	7.84	0.0001
Conductivity (µs/cm)	470 1283	< 800 ≥ 800	Domestic water Polluted water	874 1780	260 1200	588 1620	488 1590	580 1550	620 1420	425 1515	320 725	265 705	280 725	0.7015	7.71	0.0065

[1] Based upon [14]; N.B: F value = 4.789; P= 0.2336; and R^2= 0.8928; Co: Correlation

References

1. Omolade, O.O. and Adetutu S.A. Oviposition and Breeding Water Sites Preferences of Mosquitoes within Ojo area, Lagos State, Nigeria. *Biomed. J. Sci. Technical Res*., **7** (5), 6139-6145 (2018).
2. Selim, A., Radwana, A., Arnaout, F. and Khater, H. Recent Update of the Situation of West Nile Fever among Equids in Egypt after Three Decades of Missing Information. *Pak. Vet. J.,* **40** (3), 390-393 (2020).
3. Liu, X.B., Liu, Q.Y., Guo, Y.H., Jiang, J.Y., Ren, D.S., Zhou, G.C., Zheng, C.J., Liu, J.L., Chen, Y. and Li, H.S. Random repeated cross-sectional study on breeding site characterization of *Anopheles sinensis* larvae in distinct villages of Yongcheng City, People's Republic of China. *Parasit. Vectors*, **5**, 58 (2012).
4. Baz, M.M. Aquatain™, monomolecular surface film for mosquito control in unused wells breeding site. *Egypt. Acad. J. Biolog. Sci.; E. Medical Entom. & Parasitology*, **9** (1), 69-78 (2017).
5. Chandrasegaran, K., Lahondère, C., Escobar, L.E. and Vinauger, C. Linking mosquito ecology, traits, behavior, and disease transmission. *Trends Parasitol*., **36**, 393–403 (2020).
6. Fox, C. and Westneat, D. The quarterly review of biology. *Evol. Behav. Ecol.,* **85**, 504 (2010).
7. Freire, M. G., Schweigmann, N. J., Svagelj, W. S., Loetti, M. V., Jensen, O. and Burroni, N. E. Relationship between environmental conditions and host-seeking activity of *Ochlerotatus albifasciatus* (Diptera: Culicidae) in an agroecosystem and in an urban area in Chubut, Central Patagonia, Argentina. *Journal of Natural History*, **50** (21-22), 1369-1380 (2016).
8. Imam, A.A. and Deeni, Y. Common types of *Anopheles gambiae* breeding habitats in northwestern Nigeria. *J. Innov. Res. Eng. Sci.,* **4**, 496–504 (2014).
9. Nikookar, S.H., Fazeli-Dinan, M., Azari-Hamidian, S., Mousavinasab, S.N., Aarabi, M., Ziapour, S.P., Esfandyari, Y. and Enayati A. Correlation between mosquito larval density and their habitat physicochemical characteristics in Mazandaran Province, northern Iran. *PLoS Negl. Trop. Dis.*, **11** (8), e0005835 (2017).
10. Khater, H., E Soliman, D., Slim, A., Debboun, M. and Baz, M.M. Larvicidal efficacy of fifteen plant essential oils against Culex pipiens L. mosquitoes in Egypt. *Egyptian Journal of Veterinary Sciences,* 54(2), 183-192(2023).

11. Musonda, M. and Sichilima, A.M. The Effects of Ph and Temperature Parameters of Water on Abundance of Anopheles Mosquito Larvae in Different Breeding Sites of Kapiri Mposhi District of Zambia. *Acad. J. Entomol.,* **12** (1), 14-21 (2019).

12. Baz, M.M. Strategies for mosquito control. Ph. thesis, faculty of science, Benha University, Egypt, 2013.

13. Azari-Hamidian, S. and Harbach, R.E. Keys to the adult females and fourth-instar larvae of the mosquitoes of Iran (Diptera: Culicidae). *Zootaxa (Magnolia press),* **20** (78), 1-33 (2009).

14. Negm, A. M. The Nile Delta. Springer International Publishing, 537 (2017).

15. Stell, R., Torrie, J. and Dickey, D. Principles and procedures of statistics: A Biometrical Approach, 3rd ed., McGraw-Hill, New York, NY (1997).

16. Kevin, R., Daniel, K., Christine, K., Katie, F. and Alex, C. Conductivity, salinity and total dissolved solids. 2014: http://www. fondriest. com/environmental-measurements/parameters/water-quality/conductivity-salinity-tds (2016).

17. Ibrahim, A.A., El-Monairy, O.M., El-Sayed, Y.A. and Baz, M.M. Mosquito breeding sources in Qalyubiya Governorate, *Egypt. Egypt. Acad. J. Biolog. Sci.; E. Medical Entom. & Parasitology*, **3** (1), 25-39 (2011).

18. Kenawy, M.A. Review of *Anopheles* mosquitoes and malaria in ancient and modern Egypt. *Int. J. Mosq. Res*., **5** (4), 1-8 (2015).

19. EL-SHEIKH, T. M., Hammad, K. M. and Moselhi, W. A. Mosquito species diversity and abundance in relation to riceland agroecosystem and filarial infection in Kafr El-Sheikh Governorate, Egypt. *The Egyptian Journal of Hospital Medicine,* **38** (1), 100-114 (2010).

20. Elhawary, N., Soliman, M., Seif, A. and Meshrif, W. Culicine mosquitoes (Diptera: Culicidae) communities and their relation to physicochemical characteristics in three breeding sites in Egypt. *Egyptian Journal of Zoology,* **74** (74), 30-42 (2020).

21. Bashar, K., Rahman, M.S., Nodi, I.J. and Howlader, A.J. Species composition and habitat characterization of mosquito (Diptera: Culicidae) larvae in semi-urban areas of Dhaka, Bangladesh. *Pathog. Glob. Health,* **110** (2), 48-61 (2016).

22. Owolabi, D.O. and Bagbe, A.S. Assessment of Physico-Chemical and Ecological Variables in Selected Natural Breeding Sites of Mosquitoes in Ibadan, Oyo State, Nigeria. *Arch. Pharm. Pharmacal Res*., **1** (5), 1-5 (2019).

23. Kenawy, E.R. and Sakran, M. A. Controlled release formulations of agrochemicals from calcium alginate. *Industrial & Engineering Chemistry Research,* **35** (10), 3726-3729 (1996).

24. Morsy, T.A., Khalil, N.M., Habib, F.S. and El-Laboudy, N.A. Seasonal distribution of culicine larvae in Greater Cairo. *J. Egypt. Soc. Parasitol.,* **34** (1), 143-152 (2004).

25. Abdel-Hamid, Y.M., Soliman, M.I. and Allam, K.M. Spatial distribution and abundance of culicine mosquitoes in relation to the risk of filariasis transmission in El Sharkiya Governorate, Egypt. *Egypt. Acad. J. Bio. Sci.,* **1**, 39-48 (2009).

26. El-Zeiny, A. and Sowilem, M. Environmental characterization for the area under risk of mosquito transmitted diseases, Suez Canal Zone using remote sensing and field surveys. *J. Environ. Sci.*, **45** (3-4), 283-297 (2016).

27. Sowilem, M., Elshaier, M., Atwa, W., El-Zeiny, A. and El-Hefni, A. Species composition and relative abundance of mosquito larvae in Suez Canal Zone, Egypt. *Asian. J. Biol*., 1-12 (2017).

28. Kenawy, M.A., Ammar, S.E. and Abdel-Rahman, H.A. Physico-chemical characteristics of the mosquito breeding water in two urban areas of Cairo Governorate, Egypt. *J. Entomol. Acarol. Res*., **45** (12), 96-99 (2013).

29. Piyaratne, M.K., Amerasinghe, F., Amerasinghe, P. and Konradsen, F. Physico-chemical characteristics of Anopheles culicifacies and Anopheles varuna breeding water in a dry zone stream in Sri Lanka. *J. Vector. Borne. Dis*., **42**, 61(2005). PMID: 16161702.

30. Ashour, M.A., Aly, T.E. and Eldegwee, Y.A. Modeling of climatic change impact on water balance in the Nile Delta region. In GIWEH's 5th International Conference on Water, Environment & Climate Change, WECC2019, Alexandria-Egypt (pp. 1-10) (2019).

31. Kenawy, M.A., Rashed, S.S. and Teleb, S.S. Characterization of rice field mosquito habitats in Sharkiya Governorate, Egypt. *J. Egypt. Soc. Parasitol.,* **28** (2), 449-459 (1998).

32. Southgate, B.A. Recent advances in the epidemiology and control of filarial infections including entomological aspects of transmission. *Transactions of the Royal Society of Tropical Medicine and Hygiene,* **78**, 19-28 (1984).

33. Meegan, J.M., Khalil, G.M., Hoogstraal, H. and Adham, F.M. Experimental transmission and field isolation studies implicating *Culex pipiens* as a vector of Rift Valley Fever virus in Egypt. *Am. J. Trop. Med. Hyg.,* **29** (6), 1405-1410 (1979).

34. Soliman, A., Mohareb, E., Salman, D., Saad, M., Salama, S., Fayez, C. and Earhart, K. Studies on West Nile virus infection in Egypt. *Journal of Infection and Public Health,* **3** (2), 54-59 (2010).

35. Darwish, M.A., Hoogstraal, H., Roberts, T.J., Ahmed, I.P. and Omar, F. A sero-epidemiological survey for certain arboviruses (Togaviridae) in Pakistan. *Transactions of the Royal Society of Tropical Medicine and Hygiene,* **77** (4), 442-445 (1983).

36. Bayoh, M.N. and Lindsay, S.W. Effect of temperature on the development of the aquatic stages of Anopheles gambiae sensu stricto (Diptera: Culicidae). *Bulletin of Entomological Research,* **93** (5), 375-381 (2003).

37. WHO. Manual in practical Entomology in malaria, prepared by the WHO Division of malaria and other parasitic (part I). *Vector Bionomics and Organization of Anti-Malaria Activities* (1975).

38. Abdel-Hamid, Y.M., Mostafa, A.A., Allam, K.M. and Kenawy, M.A. Mosquitoes (Diptera: Culicidae) in El Gharbyia Governorate, Egypt: their spatial distribution, abundance and factors affecting their breeding related to the water, shallow depth ranging between 5–20 cm, situation of lymphatic filariasis. *Egypt Acad. J. Biol. Sci.,* **3** (1), 9–16 (2011).

39. Jemal, Y. and Al-Thukair, A.A. Combining GIS application and climatic factors for mosquito control in Eastern Province, Saudi Arabia. *Saudi Journal of Biological Sciences*, **695**, S1319-562X (16) 30013-4 (2016).

40. Emidi, B., Kisinza, W.N., Mmbando, B.P., Malima, R. and Mosha, F.W. Effect of physicochemical parameters on *Anopheles* and *Culex* mosquito larvae abundance in different breeding sites in a rural setting of Muheza, Tanzania. *Parasit. Vectors*, **10** (1), 1-12 (2017).

41. Obi, O.A., Nock, I.H. and Adebote, D.A. Biodiversity of micro invertebrates coin habiting mosquitoes habitats in patchy rock pools on inselbergs within Kaduna State, Nigeria. *J. Basic. Appl. Zool.*, **80** (1), 57 (2019).

42. Romeo, A., Victoria, O., Marcelo, D.M., Sol, F., Solari, S. and Hernán, G. Modeling the complex hatching and development of Aedes aegypti in temperate climates. *Eco. Modeling*, **253** (4), 44-55 (2013).

43. Wondwosen, B., Hill, S.R., Birgersson, G., Seyoum, E., Tekie, H. and Ignell, R. Amaizeing attraction: gravid *Anopheles arabiensis* are attracted and oviposit in response to maize pollen odours. *Malar. J.,* **16** (1), 1-9 (2017).

44. Shojaat, S. and Khamesipour, F. Anti-malarial Effect of Dracocephalum kotschyi Extract against Murine Model of Plasmodium berghei Infection. *Egyptian Journal of Veterinary Sciences,* **54**(1), 61-69(2023).

45. Youssef, A. A., Abdelgawad, A. A., Abdel-Ghany, H. S. and Abdelshafy, S. Chemical Composition of the Essential Oil from Ruta chalepensis L. Growing Wild and its Acaricidal Activity Against the Cattle Tick Rhipicephalus annulatus (Acari: Ixodidae). *Egyptian Journal of Veterinary Sciences,* **55**(4), 955-964(2024).

46. Al-abedi, H. F., Khalil, I. I. and Alhasan, D. A. H. In Vitro Effects of Laser Radiation on the Antifungal Activity of *Eucalyptus* spp. Leaves extract by chloroform. *Egyptian Journal of Veterinary Sciences,* **54**(4), 677-688(2023).

العوامل البيئية التي تؤثر على تنوع ووفرة يرقات البعوض في دلتا النيل، مصر

محمد محمود باز [1]، رويده سعيد باعشن [2]، نانسي مجدي الشوربجي [1]، وفاء محمد هيكل [2,3]، هانم فتحي خاطر [4]، أحمد بهاء الدين درويش [5]، ياسر السيد عفيفي [1] و إيمان عبد الرحمن ابوعوف [6]

[1] قسم علم الحشرات - كلية العلوم - جامعة بنها- بنها- 13518- مصر

[2] قسم علم الأحياء - كلية العلوم - جامعة تبوك - تبوك - 71491 - المملكة العربية السعودية

[3] قسم بحوث تلوث المياه - معهد بحوث البيئة - المركز القومي للبحوث – الجيزة - مصر

[4] قسم علم الطفيليات - كلية الطب البيطري - بنها - 13736 - جامعة بنها - مصر

[5] قسم علم الحيوان - كلية العلوم - جامعة السويس – السويس – 43518 - مصر

[6] قسم علم الطفيليات - كلية الطب - جامعة بنها - بنها 13518- مصر

البعوض ناقل للعديد من مسببات الأمراض التي تهدد صحة الإنسان والحيوان في جميع أنحاء العالم. هدفت الدراسة الحالية في تحديد العلاقة بين العوامل الفيزيائية والكيميائية لموائل التكاثر وتنوع ووفرة البعوض في قريتين بشمال وجنوب دلتا النيل. تم العثور على إجمالي 258 مكانًا إيجابيا لتكاثر البعوض، حيث كانت تجمعات المياه الدائمة وشبة الدائمة هي المواقع الرئيسية لتكاثر البعوض منها 46 (17.8٪) بركة، 41 (15.9٪) حوض ري، 36 (14.0٪) قناة صرف، 28 (10.9٪) بئر غير مستخدمة، 27 (10.5٪) قناة ري، 23 (8.9٪) ترعة، 22 (8.5٪) حفرة أرضية، 19 (7.4٪) مصرف، و16 (6.2٪) بركة مؤقتة في قرية برقطا جنوب دلتا النيل. كما تم العثور على إجمالي 370 مكانًا لتكاثر يرقات البعوض منها 48 (13.0٪) حقل أرز، 46 (12.4٪) بئر غير مستخدمة، 44 (11.9٪) قناة صرف، 40 (10.8٪) ساقية، 36 (9.7٪) ترعة، 34 (9.2٪) مصرف، 25 (6.8٪) بركة، 24 (6.5٪) مستنقع، 22 (5.9٪) حفرة أرضية، 21 (5.7٪) قناة ري، 19 (5.1٪) حوض ري و11 (3.0٪) بركة مؤقتة على التوالي بقرية القنطرة شمال دلتا النيل. كانت الآبار والأحواض غير المستخدمة (340.0 و278.3 يرقة / غمره) أكثر موائل التكاثر حيوية وكثافة في قرية برقطا، في حين شكلت حقول الأرز والمصارف والبرك والآبار غير المستخدمة أكبر مصادر تكاثر البعوض في قرية القنطرة واحتوت على أعلى كثافة ليرقات البعوض (619.2، 513.3، 432.5 و426.7 يرقة / غمره) على التوالي. أوضحت النتائج أن *Culex pipiens* (68.2٪) و*Cx. antennatus* (25.4٪) كانت الأكثر انتشارًا في قريتي برقطا والقنطرة على التوالي. كما بينت النتائج انتشار بعوض *Cx. pipiens* في المياه الملوثة تشير إلى وجود خطر حقيقي وإمكانية انتقال المرض على نطاق واسع لأن معظم أماكن التكاثر تحتوي على مياه ملوثة. في المقابل، وجدنا أن Cx. antennatus يتكاثر في مناطق المياه العذبة غير الملوثة مع أنواع يرقات الأنوفيليس *Anopheles tenebrosus, An. pharoensis, and An. multicolor* بقرية القنطرة شمال الدلتا. أظهرت نتائج الدراسة أن كثافة يرقات البعوض كانت مرتبطة بشكل إيجابي بدرجة الحرارة، والملوحة والنترات والتوصيلة الكهربائية. أشارت النتائج إلى أن الآبار والبرك غير المستخدمة هي مصدر واسع الانتشار وبؤر دائمة للتكاثر وإنتاجية عالية للبعوض. ويمكن الاستنتاج أن طبيعة جودة المياه تعتبر مؤشرا واضحا على وجود نوعية معينة من البعوض، بالإضافة إلى مدى تكيف بعوض كيولكس بيبنز في بيئات متعددة.

الكلمات الدالة: المعلمات الفيزيائية والكيميائية للبعوض، الوفرة، التنوع، دلتا النيل،؛ جودة المياه.