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Impact of the surface water physicochemical parameters on Culicidae (Diptera: Nematocera) of lakeside Ecosystem "Sebkhet Ezzemoul" (Oum El Bouaghi -Algeria)

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Abstract
Sebkhet Ezzemoul, wet area of international importance, is a site considered to establish a systematic inventory and study the ecology of mosquitoes. To this end, we analyzed their habitat by the determination of ecosystem surface water physicochemical parameters, followed their spatial and temporal variations and their Culicidae various species impacts. The species identified belong to two subfamilies: Anophélinae with one genus *Anopheles* and Culicinae with two genera *Aedes* and *Culiseta.* The *Aedes* genus is represented best by far particularly with the species *Aedes dorsalis* and *Aedes detritus*, which the presence is in relation to the type of prospected lodging. In this study, the salinity seems to be a parameter determining in the distribution of collected species. Results are interpreted using a Principal Component Analysis (PCA) and analysis of variance (ANOVA).

Keywords: Sebkhet Ezzemoul, Culicidae, inventory, water quality, season, Algeria.

1. Introduction
The Culicidae are insects of the order Diptera, suborder Nematocera. They are the largest group of vectors of pathogens transmissible to humans and animals. More than 3500 species described to date [1]. Ecological knowledge of the cause and spread of these diseases has helped in fighting against these vectors, to limit their actions. This is indeed the ecological study of vectors has overcome these diseases [2]. In Algeria, the bio-ecological studies on knowledge of Culicidae are very limited [3, 4, 5, 6]. For this, there have been several recent studies worldwide [7-17, 2]. Among the various places populated by these vectors, that the salt lakes, whose degree of salinity has been often very high. Numerous monographs have been devoted to the study of lakes; the best known is that of FOREL on Lake Geneva (Léman) (1892-1895) [18].
The region of the wet zones Sud-Constantinois constitutes a remarkable natural heritage because of their biological and ecological wealth. It consists of about twenty sebkha or chotts [19]. In this respect, Sebkhet Ezzemoul, international website, the station is considered to study the ecology of mosquitoes by analyzing their habitat by the determination of physicochemical parameters of ecosystem water surface and follow the spatio-temporal variations the contents of these physical chemical elements and their impact on the various species of Culicidae.

2. Material and Methods
2.1. Study site
This study was carried out in the wetland of April 2008 to March 2010, to Sebkhet Ezzemoul [35 ° 53'14 " N 06 ° 30'20"E], located in Oum -El –Bouaghi in the common Ouled Zouaï (Fig. 1), in north-eastern Algeria.
This site is a salty lake with a large salt crust. Its area is 6765 hectares and its maximum depth is 0, 40 meter. The lake is fed by rainwater drained by a watershed of 8900 ha, with water from groundwater and wastewater surrounding communities. This lake is limited by a meadow with vegetation halophilic (Salsolacées, Poaceae and Chenopodiaceae) and agricultural land for cereals. Sebkha is frequented by sheep, goats and cattle graze freely. This aquatic ecosystem is also a place of refuge for many species of waterfowl, the main ones being the flamingo Phoenicopterus roseus, Shelduck Tadorna tadorna, Ruddy Shelduck Tadorna ferruginea and

many waders like Avocet elegant Recurvirostra avosetta and stilt Himantopus himantopus [20]. The birds of water of Ezzemoul were the subject of numerous publications [21, 22, 23, 24, 25, 26].

To carry out this study, we selected several sampling stations, but the adverse conditions encountered during our surveys, we obliged to reduce the number of these deposits in three sampling stations (1, 2 and 3). The choice of these sampling stations is based on their position in relation to urban areas and especially for accessibility.

Station 1: it is a pond with grassy vegetation with little algae. It is brightened up well, sandy bottom to several meters in length and average depth. This pond is located near a flooded well.

Station 2: it's a grassy marsh littered with seaweed, airy, sunny and full of deductions (blocks, tires, bottles, containers, bags and heavy parts, etc.). This breeding site measuring 15 meters long, 9 meters wide.

Station 3: it is located close to the previous breeding site and has the same features except the dimension of length 12 meters and width of 6 meters.

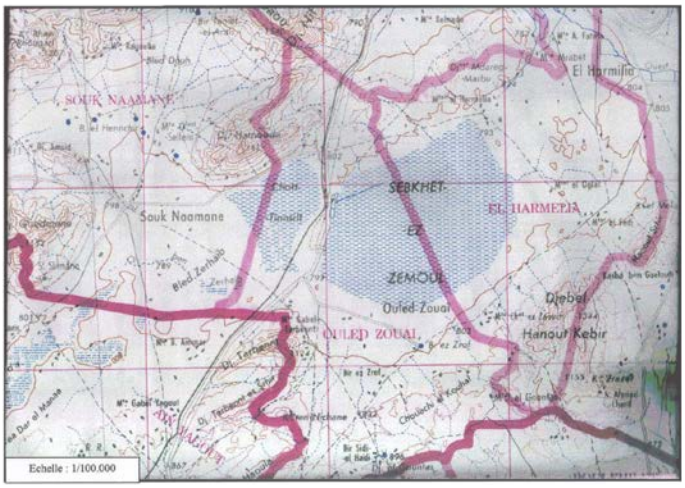

Fig 1: Localization of site study "Sebkhet Ezzemoul".

2.2. Collection of Culicidae

2.2.1. Technique of sampling

Harvesting of larvae was performed by the method of dipping [27, 28, 29, 30]. This method consists of immersing, in several places of the breeding site, a container of know n capacity (1 liter), taking into account the abundance of larvae Culicidae in these places and being careful that the medium is not disturbed. By this method, a series of shots gives us a number average of larvae per sample, the number taken as estimated average larval density per liter.

The larvae were collected every month from three stations.

2.2.2. Identification Technique

The collected larvae were preserved in labeled vials, identified and organized by deposits containing ethanol (70%), and then they were put in KOH (10%) for 12 to 24 hours for their clarification. This step is followed by rinsing with distilled water (03 baths from 2 till 5 minutes each) then through the passage in increasing alcohol concentration (70%, 90% and 100%) for 15 minutes in each concentration to remove the water contained in the sample, then the larvae were placed for at least 1 hour in beech creosote and mounted in Canada balsam.

For the taxonomic determination of the specimens, we used the identification keys for larvae proposed by [31]. The confirmation was made through Culicidae identification software Mediterranean Africa [32].

2.3. Physicochemical water stations

To understand better the ecology of Culicidae larvae, water samples taken from breeding sites were undergone analysis of the following physicochemical parameters: water temperature, pH, electrical conductivity, calcium, magnesium, potassium, sodium, bicarbonate, chloride sulfate, ammonium, nitrate, nitrite, orthophosphate and suspended matters. The measures of the 15 physico-chemicals parameters were estimated by the analytical methods proposed by [33]. These assays were performed in the Laboratory of the National Institute of Hydraulic Research (NHRI) in Constantine and the National Institute of Soil Laboratory; Irrigation and Drainage (INSID) in Oum El Bouaghi. Analyses were conducted once a month.

2.4. Ecological and Statistical treatment of the data

For the exploitation of our results, we used five ecological indices which were three ecological indices composition (species richness, relative abundance and the frequency of occurrence) and two ecological indicators of structure (Shanonn-Weaver index and evenness).

Concerning the statistical treatment, we used the Principal component analysis (PCA) and analysis of variance (ANOVA) (one- and two-factor). When H0 latter is rejected, the Fisher LSD test is used to create homogeneous groups. The objective of the PCA is to graphically represent the bulk of the information in an array of quantitative data. In a table to j data variables, individuals are in a space of dimension d. The role of PCA is to find smaller spaces minimizing these deformations [34].

For data processing by PCA, we used 15 variables (water temperature, pH, electrical conductivity, calcium, magnesium, potassium, sodium, bicarbonates, chlorides, sulfates, ammonium, nitrate, nitrite, orthophosphate and suspended matters) and 27 individuals (station 1 x 9 Water samples + station 2 x 9 Water samples + station 3 x 9 Water samples).

Adding densities préimaginales of *Aedes detritus*, *Aedes dorsalis*, *Aedes caspuis*, *Aedes mariae*, *Aedes vexans*, *Anopheles sergenti and Culiseta longiareolata* as additional variables used to study the relationship between these species and the physicochemical characteristics of these sampling stations.

The statistical analyses were carried out using XLSTAT 2006 software.

3. Results

3.1. Inventory Culicidae

The systematic inventory of Culicidae mosquitoes collected to Sebkhet Ezzemoul, in the sampling stations, revealed after identification the presence of seven species belonging to two subfamilies: Anophélinae and Culicinae.

The subfamily Culicinae appeared the most species-rich; it is divided between two genera: the *Aedes* genera with five species (*Aedes (Ochlerotatus) dorsalis* Meigen 1830, *Aedes (Ochlerotatus) detritus* Haliday 1833, *Aedes (Ochlerotatus) caspius* Pallas 1771, *Aedes (Ochlerotatus) mariae* (Sergent & Sergent 1903), *Aedes vexans* Meigen 1830); the Culiseta genera represented by a single species: Culiseta longiareolata Macquarts 1838 (table 1).

The subfamily Anophelinae is represented by one genera, *Anopheles* with the species *Anopheles sergenti* Theobald 1907 (table1).

Table 1: List of the species of Culicidae collected at the level of the site Sebkhet Ezzemoul (April 2008 - March 2010).

Sub-family	Genera	Species
Culicinae	*Aedes*	*Aedes dorsalis (Ochlerotatus)* Meigen 1830
		Aedes detritus (Ochlerotatus) Haliday 1833
		Aedes caspius (Ochlerotatus) Pallas 1771
		Aedes mariae (Ochlerotatus) *(*Sergent & Sergent 1903)
		Aedes vexans Meigen 1830
	Culiseta	*Culiseta longiareolata* Macquart 1838
Anophelinae	*Anopheles*	*Anopheles sergenti* Theobald 1907

3.2. Ecological Analysis of the culicidienne fauna

Seven species of Culicidae were identified (Table 2); two species were dominants by their abundance and frequency, *Aedes dorsalis* (59.65%, 41.18%) and *Aedes detritus* (34, 34%, 35, 29%), followed by *Aedes caspius* whose relative abundance is 2, 30% and the occurrence frequency is 07.84%. As against the other species *Culiseta longiareolata* (1,59%, 1,96%), *Aedes vexans* (0,71%, 5,88%), *Aedes mariae* (0,71%, 3,92%) and *Anopheles sergenti* (0,71%, 3,92%) were scarce and poorly represented.

This site is marked by the presence of two species Accessories which were *Aedes dorsalis* and *Aedes detritus* all other species were Accidental.

Species diversity was evaluated using Shannon-Wiener index (H) and Evenness index (E) (table 2). The value of Shannon–Weiner index was 0, 42 bit remains below the maximum diversity (H max) (0, 85). This reveals the existence of a little diversified population Culicidienne. The Evenness index (E) equal to 0.49, or 49%, implies the existence of a moderately balanced relationship between the different species that make up the Culicidien population.

Table 2: Ecological indices of composition and structure of the species of Culicidae collected at the level of the site Sebkhet Ezzemoul (April 2008 - March 2010).

Site	Sebkhet Ezzamoul		
Species	**Nind%**	**Occ%**	**Caté.**
Aedes dorsalis	59.65	41.18	Acces
Aedes detritus	34.34	35.29	Acces
Aedes caspius	2.30	7.84	Accid
Aedes vexans	0.71	5.88	Accid
Aedes mariae	0.71	3.92	Accid
Anopheles sergenti	0.71	3.92	Accid
Culiseta longiareolata	1.59	1.96	Accid
total	100	100	
H'			-0.42
H'max			0.85
E			0.49

% Nind: the relative abundance; % Occ: the frequency of occurrence; Caté: category; Access: accessory; Accid: accidental; H': index of Shanonn-Weaver; Hmax: maximal diversity; E: index of equitability (Evenness index)

3.3. Global study of the physico-chemical parameters

The analysis mesologique global of the medium is approached by the Principal Component Analysis (PCA) (Fig.2).

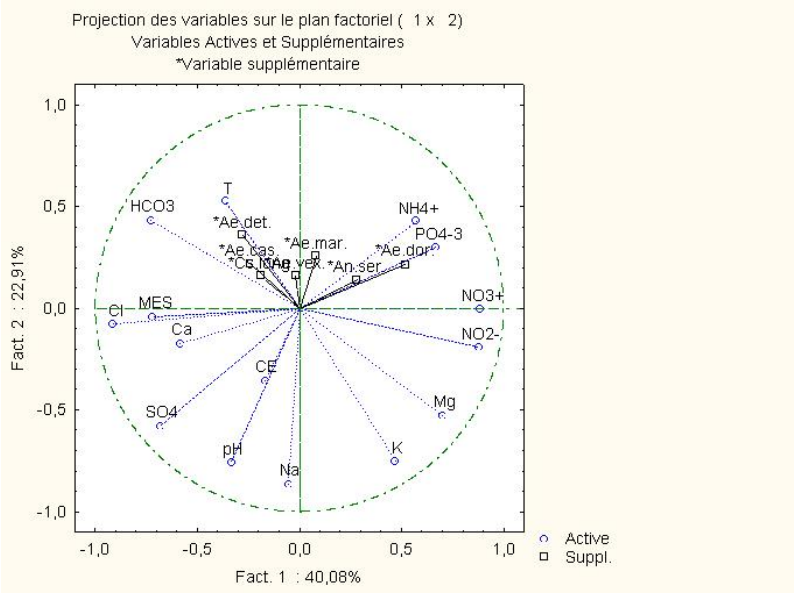

Fig 2: Projection of variables on the plan Factorial F1x F2.

Analysis of physico-chemical data shows that the percentage of inertia of the first three main areas totaling 76, 46% Information on the distribution of physicochemical variables and studied stations. The axis F3 was not retained because of its low percentage (13, 47%).

The factorial plan F1xF2, representing 62, 99% of the total information. The first axisF1 represents 40, 08% of this information, it is determined by the nitrate, nitrite, magnesium, orthophosphate, ammonium opposed to the chloride, bicarbonate, suspended matters, sulfate and calcium. According to these characteristics, the first axis F1opposes sampling stations polluted and less chlorinated to sampling stations not polluted rich in chlorides and loaded in particles (Fig 2). The second axis F2 contains 22, 91% of the total inertia, it is formed by the temperature, sodium, pH, potassium and electrical conductivity. The second axis opposes sampling stations weakly salted to sampling stations highly salted (Fig 2).

3.4. Analysis spatiotemporal

To define exactly the groups of breeding sites according to the meaning of axes defined previously by A.C.P., we used one-way analysis of variance for each physicochemical parameter. The electrical conductivity was the only physicochemical parameter which presents a significant difference between the three sampling stations ($p < 0.05$) (Table 3).

Table 3: Mean values of the physico-chemical parameters measured in the sampling stations of study.

Variable	Station 1	Station 2	Station 3	ANOVA *F*-value	Probability (*p*)
Water température (°C)	26.00 ± 5,83	23.33 ± 8.06	24.78 ± 7.48	0.31	> 0.05
pH	8.00 ± 0,61	7.74 ± 0.53	7.77 ± 0.59	0.54	> 0.05
Electrical conductivity (µs/cm)	45933.33 ± 8279.22	29867.78 ± 329.80	31766.67 ± 362.00	**5.02***	**< 0.05**
Orthophosphate (mg/l)	8.96 ± 11.38	6.72 ± 7.53	11.17 ± 19.82	0.23	> 0.05
Ammonium (mg/l)	0.85 ± 0.66	1.19 ± 1.04	1.00 ± 0.59	0.42	> 0.05
Nitrite (mg/l)	17.54 ± 16.63	14.40 ± 12.99	15.39 ± 13.92	0.11	> 0.05
Nitrate (mg/l)	37.58 ± 34.96	49.29 ± 30.14	45.11 ± 26.16	0.34	> 0.05
Suspended matters (mg/l)	0.91 ± 1.64	0.33 ± 0.45	0.27 ± 0.37	1.09	> 0.05
Calcium (mg/l)	1516.41 ± 1229.29	1478.28 ± 1088.30	1078.28 ± 998.45	0.43	> 0.05
Magnesium (mg/l)	7574.85 ± 8594.31	8010.93 ± 8986.71	6884.26 ± 8085.70	0.04	> 0.05
Sodium (mg/l)	7937.854 ± 499.03	6486.09 ± 3962.48	7436.06 ± 4376.78	0.03	> 0.05
Potassium (mg/l)	531.60 ± 732.02	626.41 ± 904.13	500.56 ± 738.80	0.06	> 0.05
Sulfate (mg/l)	3.49 ± 2.57	3.30 ± 2.035	3.99 ± 2.66	0.19	> 0.05
Chlorure (mg/l)	5994.21 ± 8465.33	3488.19 ± 4073.38	3305.42 ± 3816.72	0.59	> 0.05
Bicarbonate (mg/l)	59.42 ± 32.66	69.63 ± 56.58	64.56 ± 54.11	0.1	> 0.05

F-value: value of the variable of F of FISHER; (*) indicates significant difference.

Based on the comparison index averages with the LSD Fisher test, we identified two groups of sampling stations:

Group 1: It is consisted by the sampling station 1, characterized by heavily salted (average conductivity 45933, 33 µs / cm) (Table 4).

Group 2: it is represented by the sampling stations 2 and 3, weakly salty. However, the sampling station 3 was a sampling station whose conductivity was higher (average 31766, 67 µs / cm) than in the sampling station 2 (on average in 29867, 78 µs / cm) (Table 4).

Table 4: Mean comparisons of physico-chemical characteristics by the test LSD of Fisher at the threshold of 5 %, obtained during 2 years in the three stations sampled.

stations	CE (µs/cm)	Na^{+} (mg/l)	Cl^{-} (mg/l)	PO_4^{-3} (mg/l)	NO_2^{-} (mg/l)	NO_3^{-} (mg/l)	SO_4^{-} (mg/l)	Ca^{+2} (mg/l)	Mg^{+2} (mg/l)
station1	45933.33 (a)	7937.85 (a)	5994.21(a)	8.96 (a)	17.54 (a)	37.58 (a)	3.49 (a)	1516.41(a)	7574.86 (a)
Station2	29867.78 (b)	7597.20 (a)	3488.19 (a)	6.72 (a)	14.40 (a)	49.29 (a)	3.30 (a)	1478.28 (a)	8010.93 (a)
station3	31766.67 (b)	7436.06 (a)	3305.42 (a)	11.17 (a)	15.39(a)	45.11 (a)	3.99 (a)	1078.28 (a)	6884.26 (a)

3.5. Biotypological analysis

The impact of the physico-chemical characteristics of the water on the larval densities of the species collected of culicidae is discovered by the analysis of the variance to two factors.

The results stemming from the analysis of the variance in two factors show that the global density of the collected species was significantly different in three sampled stations ($p < 0, 05$) and the test LSD of Fisher allows to individualize two groups. The first one contains the species *Aedes dorsalis* and *Aedes detritus* where as all other species belong to the second group (table 5).

Table 5: Creation of the groups for the species collected by the test LSD of Fisher at the threshold of 5 %, obtained during 2 years in the three stations sampled.

Species	Average	Groups	
Aedes dorsalis	10.22	a	
Aedes detritus	7.19	a	
Aedes caspius	0.30		b
Aedes mariae	0.15		b
Aedes vexans	0.07		b
Anopheles sergenti	0.11		b
Culiseta longiareolata	0.33		b

a: The first group; b: The second group

The species *Aedes dorsalis* and *Aedes detritus* behave in the same way when salinity is low (stations 2 and 3). But as soon as the salinity exceeds a certain threshold (EC average 45933, 33µs/cm) (station 1), both species behave differently, the first species is more tolerant to variations in salinity that the second species (Table 6).

Table 6: Mean comparisons of the larval densities of the species collected by the test LSD of Fisher at the threshold of 5 %, obtained during 2 years in the three stations sampled.

stations	*Aedes dorsalis*	*Aedes detritus*	*Aedes caspius*	*Aedes mariae*	*Aedes vexans*	*Anopheles sergenti*	*Culiseta longiareolata*
Station 1	9.67 (ac)	3.22 (bc)	0.11 (bc)	0.11 (bc)	0 (b)	0 (b)	1 (bc)
Station 2	3.56 (bc)	5.56 (c)	0.33 (b)	0.33 (b)	0.22 (b)	0 (b)	0 (b)
Station 3	17.44 (d)	12.78 (ad)	0.44 (bc)	0 (b)	0 (b)	0.33 (b)	0 (b)

In the three stations sampled, the highest densities of Culicidae were recorded in September in station 1, May in stations 2 and April in station 3. Lower densities were recorded in Jun for station 1 and January for stations 2 and 3.

3.6. Correlation between physicochemical parameters and larval densities of Culicidae

The relationship between harvested species and 15 physicochemical parameters is analyzed by the global study of the medium (Fig.2). The coefficients of correlation established from the global analysis between the various sampled physico-chemical parameters and the larval densities of the species collected of culicidae appear on the table 7.

The larval density of *Aedes dorsalis* is positively correlated to phosphate (r = 0,596), nitrite (r = 0,507), nitrate (r = 0,471) and negatively correlated with the calcium (r = - 0,574), sulfate (r = -0,454), chloride (r = -0,415) and bicarbonates (r = -0,321) while that of *Aedes detritus* is negatively correlated to the sodium (r = -0,492), electric conductivity (r = - 0,467), nitrite (r = - 0,420), nitrate (r = 0,388) and the magnesium (r = - 0,416). The orthophosphate and nitrite are thus the most important parameters which favor the proliferation of *Aedes dorsalis*.

For the species *Anopheles sergenti*, their larval density is positively correlated with orthophosphate (r = 0,782) and the magnesium (r = 0,338) and negatively correlated with sulfate (r = 0,293). Concerning the other species which are *Aedes caspius*, *Aedes vexans*, *Aedes mariae* and *Culiseta longiareolata*, they have low correlations with the studied physico-chemical parameters.

Table 7: Correlation coefficients between the various physico-chemical parameters and the larval densities of the species of culicidae collected.

	T (°C)	Ph	CE	PO_4^{-3}	NH_4^+	NO_2^-	NO_3^-	MES	Ca^{+2}	Mg^{+2}	Na^+	K^+	SO_4^-	CI^-	HCO_3^-
Aedes dorsalis	-0.192	-0.230	-0.067	0.596	0.211	0.507	0.471	-0.315	-0.574	0.108	-0.319	0.012	-0.454	-0.415	-0.321
Aedes detritus	0.213	-0.043	-0.467	-0.219	-0.271	-0.420	-0,388	0.064	-0.088	-0.416	-0.492	-0.298	0.024	0.081	0.282
Aedes caspius	0.141	-0.060	-0.260	-0.207	-0.191	-0.343	-0,226	0.084	0.035	-0.277	-0.267	-0.219	0.035	0.133	0.276
Aedes mariae	-0.035	-0.267	0.035	0.058	0.080	0.122	0,107	-0.064	-0.260	-0.223	-0.287	-0.182	-0.188	-0.037	0.011
Aedes vexans	-0.091	-0.148	-0.019	-0.020	-0.042	-0.016	-0,042	-0.055	-0.242	-0.247	-0.176	-0.203	-0.032	0.068	-0.022
Anopheles sergenti	-0.077	-0.182	0.042	0.782	0.204	0.091	0,180	-0.074	-0.092	0.338	-0.054	-0.141	-0.293	-0.123	-0.180
Culiseta longiareolata	0.180	-0.055	-0.114	-0.131	-0.023	-0.218	-0,288	0.220	0.159	-0.172	-0.177	-0.137	0.017	0.100	0.114

4. Discussion

Our study was completed by the determination of three cosmopolitan species which were *Aedes dorsalis, Aedes detritus and Aedes caspius*. The first two species had a vast distribution. Contrary to the species *Aedes dorsalis* and *Aedes detritus*, the species *Aedes caspius*, *Aedes mariae*, *Aedes vexans*, *Anopheles sergenti* and *Culiseta longiareolata* appeared as very rare (tab. 2).This rarity can be explained the power of tolerance of every species to the station which it colonizes and by the physico-chemical characteristics of this station. They showed weak correlations to these characteristics.

The presence of the favorable stations determines the presence of the species [35]. In view of the studied physico-chemical parameters, both species *Aedes dorsalis* and *Aedes detritus* seem to be attracted by weakly salted waters (station 3), what is translated by a fast development and an intense proliferation in the region. The salinity makes breeding sites more conducive to vector species *Aedes dorsalis* and *Aedes detritus* that are significantly halophilic species. The presence of *Aedes dorsalis* in the same types of breeding sites where the water is strictly salted has already been reported by [32], which reveal the existence of this species in ponds and wetland where the water is brackish or salt. It was usually identified from February to November [14]. We were able to detect it in February, March, April, September and October. This species has a discontinuous development during spring, autumn and winter periods and a break in the summer.

In second position comes the *Aedes detritus* species with 34, 34 % abundance. It was a discontinuous development in spring, autumn and winter to be interrupted in the summer. According the authors [36, 37, 38], this species has a winter-automno continuous development.

The *Anopheles* genus is represented by a single species *Anopheles sergenti*. This species was found only in the fall (03 individuals in October and 01 individual in November) in weakly salted waters, poor in chloride and rich in nitrite, nitrate and phosphate (station 3), in slightly alkaline pH (7,24-7,32) and low temperature (10 C - 22 °C). According to our results of correlation, the phosphate is the most important parameter which favors its proliferation. The high phosphorus concentrations testify of an organic pollution from human and industrial origin and illustrate how the ecosystem defends itself by the self-purification to fight against eutrophication [39]. These results are not in agreement with those of [40, 41, 14, 15] who argue that the *Anopheles* larvae prefer fresh water, well oxygenated, at elevated temperature with low levels of phosphorus elements. She was found in low densities (less than 10 individuals), especially during the months of June, July and August [14].

The *Culiseta* genus contains a single species *Culiseta longiareolata*. Larvae of this species appeared only in the spring (09 individuals in May) in strongly salted waters (station 1), at pH slightly alkaline (7.68). The larvae of this mosquito can colonize a wide variety of breeding sites whether permanent or temporary, shady or sunny, filled with fresh or brackish water, clean or polluted such as ponds, troughs, abandoned wells, hollow rocks, paddy fields, canals [32]. [42] argues that *Culiseta longiareolata* is a common species in almost all types of breeding sites from June to November. However [37] states that this species presents an automno-winter-spring continues development.

The rise in temperature during the summer (30°) was the main factor of intense evaporation in the sampling station 1,

therefore, it was the principal agent of increased salt concentrations in water (83100 µs/cm) and the total absence of Culicidae larvae. The temperature and salinity can thus promote or limit the growth of larvae [38]. Temperature affects the degree of evapotranspiration and therefore it acts on the water salinity [43]. Vector distribution is particularly limited by the minimum and maximum temperatures that prevent their survival from one season to another [44]. However, no Culicidae larvae were collected during surveys of sampling station 2 and 3 in November, December and January. This disappearance of the larvae despite the presence of water could correspond to a judgment of oviposition in females who survive. For the sampling station 1, in winter (November and December), the densities were nil because of the drying out of this sampling station.

The pH of the water reflects the biological activity of the medium because it influences the manufacturing of the organic matter (alkalinization of the medium) [39] or degradation of organic matter (acidification of water) [39], for which generally indicates a pH between 5 and 9 [33] and between 6.5 and 8.5 [45]. According our results the pH is between 6.89 and 8.88 does not seem to play a role in the control of larval development; the larvae harvested of culicidae species develop at basic pH. Our results coincide with those of [4] and did not corroborate with those of [46], these authors point out, in fact the influence of pH on the control of larval development, unlike our investigations.

Orthophosphate, nitrite and nitrate were the most important parameters which favored the proliferation of the larvae of *Aedes dorsalis* because the highest densities were recorded in autumn and the lower densities were recorded in spring. The reduction marked in spring is due to either to degradation by the microbial flora or to a dilution or to haste. The authors [13] suggest that, in the 'positive' breeding site where mosquito larvae ingest organic matter, water turbidity decreases, which allows the organic nitrogen to move towards the way of the mineralization ($NH_4^+ \rightarrow NO_2^- \rightarrow NO_3^-$) via the activity of nitrifying bacteria. Ion processing ammonium to nitrite and then to nitrate requires a high oxygen demand. These oxidation reactions explain the low dissolved oxygen content found in the "positive" breeding site. The medium uses nitrate as an oxygen source for mineralization and self-purification and therefore its ecological balance [39].

Between the three stations sampled there were variations and differences of the larval densities which allowed distinguishing the preferential biotopes for certain species.

The larval density of the collected species was higher in the sampling station 3 (weakly salted) than in the sampling station 1(strongly salted) and the sampling station 2 (weakly salted). Nevertheless, the sampling station 3 is a sampling station the conductivity of which is higher (on average 31766, 7 µs / cm) than in the sampling station 2 (in moyenne2986, 8 µs / cm). The strong larval densities of the inventoried species are associated with low contents in salts in waters of sampling stations. The larval densities of *Aedes dorsalis* and *Aedes detritus* were very different from other harvested species. The species *Aedes caspius*, *Aedes mariae*, *Aedes vexans*, *Anopheles sergenti* and Culiseta longiarolata were similar.

According to the value of the index of diversity of Schannon (0, 42 bit) which was lower than that of the maximal diversity (0, 85), Culicidae was little diversified and the specific wealth was less important. The low diversity can be explained by the dominance of both species *Aedes dorsalis* and *Aedes detritus* on the other collected species and the nature of their larvae breeding sites, which didn't seem to be prolific in larvae of Culicidae. Thus the index of diversity takes into account the representativeness of every species. However the value of the index of equitability was 0, 49 or of the order 49%, this implies the existence of a populating Culicidienne averagely balanced.

The influence of the physicochemical characteristics of breeding sites of colonization by different culicidiennes species has already been noted [47, 28, 46, 48, 8, 13, 15, 49, 4, 17, 50].

5. Conclusion

In our study, there were two factors limiting the presence of culicidiennes populations: the season and the water quality of the deposits. These analyses revealed two groups of stations and species according to various parameters, especially salinity.

The results showed that the physical and chemical nature of the water sampling stations condition the presence or absence of culicidae larvae. These results should be considered in developing an adequate program against mosquito's sources of pollution.

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