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Some physical and chemical conditions affecting the ecology of mosquitoes (Diptera, Culicidea) in the gharb's plain and in the cities of rabat and salé (Morocco)

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ABSTRACT

The Gharb plain is one of the richest areas in surface water. This wealth promotes great biodiversity of aquatic and aerial fauna,especially the Diptera Culicidae insects. Unfortunately, many species of these flies are harmful by their bites and by their possibility of transmitting diseases to humans and animals. So, the knowledge the ecology of these insects is useful for any fight against pests. In this work we are interested in studying the influence of the main physico-chemical factors in the ecology of larvae of 13 species of Culicidae which were harvested in ten major hydro-systems located in the Gharb plain and the urban areas of both cities Rabat - Salé (Morocco). The results showed that the water temperature, pH, conductivity, total alkalinity, its calcium and magnesia hardness, its degree of oxidizability, the concentrations in water of chlorides, nitrates and nitrites all combine their influences to determine their effects favorable, or unfavorable, on the development and the geographical distribution of species. Thus, for a given environment, if the physico-chemical conditions are known, we could deduce the potential systematic structure of the settlement in Culicidae Diptera of this environment. © 2015 Trade Science Inc. - INDIA

KEYWORDS

Diptera culicidae;
Physicochemical factors;
Ecology;
Plain gharb;
Rabat / Salé;
Morocco.

INTRODUCTION

The habitat has many constraints on the species that live there through the action of several abiotic factors also appointed filters local habitats such as temperature, oxygen, pH[1]. Thus, for any species, the evaluation of some physico-chemical characteristics are very useful to determine the species preferences of habitat types; so, we could acquire much information which is necessary for a better managing the medium in question.

Therefore, to determine the main factors that contribute in the physicochemical conditions affecting the ecology of thirteen Diptera Culicidae mosquitoes, in-

cluding many species which are harmful to humans or animals through their bites or power transmission of pathogens of parasitic diseases such as malaria, we have evaluated the values of ten physicochemical parameters in many biotops. Then, in order to highlight the various correlations existing between the various parameters evaluated a treatment of all results was performed by a statistical multivariate method: Principal Component Analysis (PCA). We recall that the main goal of this method has been to condense the essential information contained in the original variables often correlated with a smaller number of new variables called principal components[2-5]. The same method allows to develop a typology of physicochemical habitats studied has already been applied to the physicochemical characteristics of inland waters by several authors including[6-8]. Therefore, to determine the main factors that contribute in the physicochemical conditions affecting the ecology of thirteen Diptera Culicidae mosquitoes, including many species which are harmful to humans or animals through their bites or power transmission of pathogens of parasitic diseases such as malaria, we have evaluated the values of ten physico- chemical parameters in many biotops. Then, in order to highlight the various correlations existing between the various parameters evaluated a treatment of all results was performed by a statistical multivariate method: Principal Component Analysis (PCA). We recall that the main goal of this method has been to condense the essential information contained in the original variables often correlated with a smaller number of new variables called principal components[2-5]. The same method allows to develop a typology of physicochemical habitats studied has already been applied to the physicochemical characteristics of inland waters by several authors including[6-8].

MATERIALS AND METHODS

Studied sites and stations

Ten of the important aquatic systems in the plain of Gharb or nearby the cities of Rabat and Sale were prospected. According to their heterogeneity, one or many stations were studied at each of them.

Lac Sidi Bougha

Since 1964, it was ranked by IWRB as a natural site of international importance for waterfowl, and as a biological reserve by the Administration of Forestry and Soil Conservation. It was also listed as "Ramsar site "since 1974. It is a natural accumulation of standing water nearby the Atlantic coast of Morocco. It is located 3 km south of the city of Kenitra, 35 km north of the city of Rabat and occupies the center of a reserve, the reserve of Sidi Boughaba, which is a wetland of international importance for migratory waterbirds.

The lake is about 6 km long and could be divided into four areas having different environmental conditions[2]:

- Temporary pond of Sidi Boughaba: It is a circular depression about 1 hectare of surface having a muddy bottom. It is surrounded by a dense vegetation of *Juncus maritimus* with a few feet of *Scirpus lacustris* and its flooding is performed by the rainwater. The algal vegetation is rich in *Chara canescens* and *Chaetomorpha linum*.
- Small Merja: it is a brackish semi-permanent Swamp, which has duration of flooding up to 7 months. It is a depression about 6 hectares located north of the main lake. The water depth could reach 0.7 m and peripheral vegetation is mainly formed by *Juncus rigidus* mixed with a few feet of *Scirpus lacustris*.
- The main-lake: It is the permanent part of the lake and it is a length of about 4 km, the water is not brackish and the peripheral vegetation is abundant.
- Permanent ditch Sidi Bou Ghaba: It has a gap of 3 to 4 m diameter, the water is permanent and 1.5 m deep. It is located at the southern end of the main lake Sidi Bou Ghaba. The water is very salty and can communicate with the main lake when it swells after heavy rainfall. Mainly, the aquatic vegetation consists of *Lemna gibba* and *Chaetomporpha linum,* and the edge of *Juncus maritimus*.

Lac fouarate

It is a wetland located northeast of the city of Kenitra, which is, according Lahrouz et *al*. (2012)[6], a wintering area for migratory birds. Its area is 2.16 km^2 and it is a depth of 0.5 to 4 m invaded with vascular vegetation and filamentous algae and its impoundment is provided by the inflows of the river Fouarate, water from the outcrop of the aquifer in the winter, the water of precipitation and the wastewater[7]. In addition, the lake is the ultimate repository for many releases and waste from densely populated surrounding neighborhoods and where are located several small industrial units (textiles, tanneries,…).

According to the apparent heterogeneity of the lake, three research stations were surveyed:

1 S1: It is located upstream of the lake on the river Fouarat. This site is considered as a reference site.
2 S2: It is located at Lake Fouarat, respectively, on the right bank near crop fields;
3 S3: It is located near the outfall wastewater of the surrounding neighborhoods.

The temporary pond and the well of sidi amira

It is located about 15 km east of Rabat, near the forest home of Sidi Amira. It is a flat bottom trough. The aquatic vegetation appears as soon as the impoundment begins. The vegetation consists of hygrophilles herbaceous species, Characeae (*Chara canescens*) and other filamentous algae (*Spiroger sp.*). The vegetation consists of phanerogammes including *Ranunculus aquatilus* and *Glyceria fluitans*.

Sidi yahia

It is in Beht river at the Sidi Yahia of Gharb. It is a river that in this city receives wastewater of the city. Often, the water flow is not too high except during the rainy season. In places, herbaceous vegetation or submerged filamentous algae is present.

Oued fekroun

It is an artificial river dug into the ground to drain the excessive irrigation water and water of the runoff or floods. It is located fifteen kilometers north of the city of Kenitra. The flow of water has been often low; the algal and vascular vegetation is often very developed. Similarly, in places, the water surface is covered with duckweed; the water depth is often less than 80 cm.

Dayet zdegh

It is a semi-permanent pool of an area of 2 hectares which is located 7 km east of the city of Kenitra. The water depth can reach one meter and the aquatic vegetation is rich in filamentous algae and *Ranuculus aquatilis*.

Gite oulja rabat

It is a temporary to semi-temporarily swamps which receiving sewage from the city of Rabat. Salinity varies from one place to another according to the heterogeneity of the medium and the amount of freshwater received. The richness of the environment of the aquatic vegetation varies according to the degree of local salinity and water depth can reach 0.80 meters.

Daya oulja sale

It is a temporary pond contaminated by water from leaching from the disposal of solid waste in the city of Salé. Salinity is not too high the vegetation consists of filamentous algae and *Ranunculus aquatilis*. Water depth is up to 1 meter.

Dar El gueddari

Dar El Gueddari is a small village in the plain of Gharb very prone to flooding or storm of Sebou river. Thus, ditches and temporary pools are very common. Aquatic vegetation consists of filamentous algae, *Ranunculus aquatilis* and duckweed (*Lemna gibba*).

Rice fields

In Morocco, the fields of rice are located in the Gharb plain. Their area is estimated at 13 000 ha. It is an agro-ecosystem that is flooded during the growing season of rice (late April to mid-September) and dried up the rest of the year.

Studied physicochemical parameters

The influence of ecological factors of the environment on general physicochemical processes and in particular on the life cycle of the geographical distribution of species, has been reported by many authors. It is therefore useful to evaluate the effect of the main factors that have an influence on the ecology of mosquitoes. Thus, in each gites, or station when the environment is heterogeneous, we have evaluated eleven physi-

cochemical parameters. This is the temperature (Tp), the pH, the conductivity (Cd), the content of nitrate, nitrite content, dissolved oxygen (O2), chlorides (Cl-), alkalinity (Alc), Calcium Hardness (Ca++), the hardness magnesium (Mg++) and total hardness (DT).

Statistical methods for data processing

In order to determine the set of physicochemical parameters influencing the characteristics of the water and to identify the similarities between habitats surveyed, we processed the data obtained by the Principal Components Analysis (PCA) which is a factorial method, based on the analysis of correlations between the variables by a construction of the new synthetic axes or principal component that are derived by linear combination of the original characters.

This method has been widely used in many works of Biology; we include the work Hammada et *al*., Abba et al.[13] Ouzair et al.[14] and Hbaiz et *al*.[15].

Sampling and methods of analysis of the water

We conducted in situ measurement of the water temperature (Tp), electrical conductivity (Cd), dissolved oxygen (DO) and pH with field devices. The other variables were analyzed in the laboratory. Assays are either volumetric or by spectroscopic methods, and analytical methods were such as they were proposed by Rodier[16]. These variables are Nitrites (Nit), Nitrates (Nat) Title alkalimetric Full (TAC), the content of calcium (Ca + +), the content of magnesium (Mg + +), Title Hydrometric (TH) and chloride content (Cl-).

Elaboration of the data matrix

For eleven physicochemical parameters evaluated, the overall results are shown in TABLE I. The same table was used as template data statistically treated. Therefore, it is a data matrix consisting of a double-entry table "10 Variables x 17 Samples." The codes of eleven physicochemical parameters and the numbers of the samples which were taken are shown in TABLE II.

Similarly, in order to develop a biotypology study of harvested species, the matrix containing the geographical distribution of mosquito species which were collected in the 16 studied stations was statistically treated by a multivariate statistical analysis.

Note that the confrontation of the results of the typological study of the biotypologique study allows determining the influence of the physicochemical conditions of the environment on the geographical distribution of the species studied. The statistical software used

TABLE 1 : Data matrix grouping the estimated values of the physicochemical variables within 18 sampling

Codes	Tp	pH	O2	Cd	Ca++	Mg++	Cl-	Alc.	Oxyd.	Nitrates	Nitrites
DED	20,2	6,2	8,7	163,4	8,4	6,59	111	55	55	12,1	0,61
DSA	21	6,7	13	807	11,1	29,4	154	58	65,8	11,7	0,26
PSA	19,2	6,1	6,7	248	8,8	36,9	109	67	52	15,1	1,42
GMSB	19	6,6	11	3107	27,1	45,7	507	68	71	10,9	0,97
PMSB	19,1	8	9	3951	11,6	50	3567	85,2	69	13.5	0,54
DSB	19,5	7,4	13	2900	7,5	4,8	614	98,3	44,2	12,3	0,25
FSB	18,9	7,5	10	3120	8,1	9,3	732	99,2	51,5	12,3	0,34
DZ	19,4	6,5	9,8	866	18,3	3,3	344	37,7	65	10,1	0,29
OF	21	7,8	11,2	1360	28	28,9	97	58,1	68	11,6	0,48
OSY	21,7	7,6	10,4	1960	29	16,09	98	57,3	51	11,1	0,18
DG	20,1	7,9	9,2	1212	30	9,02	88	62,1	42	10,6	0,19
RIZ	25,1	7,9	8,6	1520	25	8,8	86	180	22	7,5	0,15
MFS1	23	7,32	5,9	1224	17	11,4	175	94	16,4	7,83	0,14
MFS2	24	7,9	4,9	1530	139	16,2	181	107	17,7	16,5	0,19
MFS3	14	8,1	3,7	1940	147	17,3	237	212	28,2	13,6	0,15
OULJR	19,1	8,4	8,7	1770	216	31,3	474	190	16,8	8,94	0,29
OULJS	20	8	6,7	1696	200	11,6	573	87,3	17,9	13,5	0,24

TABLE 2 : Data matrix grouping species harvested in the studied stations

Cottages	Stations	*Anopheles labranchiae*	*Culex pipiens*	*Culex hortensis*	*Culex theileri*	*Culex modestus*	*Culex impudicus*	*Culiseta longiareolata*	*Culiseta annulata*	*Culiseta subochrea*	*Ochlerotatus caspius*	*Ochlerotatus detritus*	*Uranotaenia b alfouri*	*Uranotaenia unguilata*
Sidi Bou Ghaba	S1				+							+		
	S2										+	+	+	
	S3		+											
	S4		+							+	+	+		+
	S5		+											
Fouarate	S6		+										+	
	S7		+											+
Oued Fekroun	S8	+	+		+									
Sidi Amira	S9 Da	+	+		+	+	+	+						
	S10 Puit		+		+		+	+	+					
Dayet Eddis			+		+	+								
Dayet Zdegh	S11	+	+			+					+			
Sidi Yahya	S12	+		+				+	+					
Dar Gueddari	S13			+	+									
Oulja de Salé	S14	+	+					+						
Oulja de Rabat	S15	+	+											
Ricefields	S16	+	+		+									

TABLE 3 : Eigenvalues and percentages of inertia explained by the first three axes

Factorial axes	C1	C2	C3
Eigenvalues	3,470	2,263	2,152
Variance (%)	31,543	20,573	19,561
Cumulative (%)	31,543	52,116	71,677

for this analysis is the "SPSS".

RESULTS AND DISCUSSION

According the results (TABLEs III and IV; figures 2 and 3), we find that most of the information is explained by the three first factorial axes. Respectively, the contributions of the variables in the formation of the first three factorial axes C1, C2 and C3 are 31.543%, 20.573% and 19.561%, forming a total of 71.677% of the information explained. Thus, the maximum cumulative inertia is explained by the planes formed by the factorial axes C1 × C2 and C1 x C3. Moreover, the physicochemical meaning of factorial axes C1, C2 and C3 are required.

Meaning of the axes of A C.P.

TABLE 4 : Degree of correlation between variables and the first three factorial axes

Variables	Axes		
	C1	C2	C3
Oxyd	-0,863	0,261	0,268
Ca	0,855	-0,004	0,150
Alc	0,806	0,177	-0,077
O2	-0,737	0,297	-0,337
pH	0,725	0,489	-0,313
Cd	0,057	0,915	-0,001
Cl	-0,071	0,828	0,249
Nitrites	-0,457	-0,112	0,753
Nitrates	0,104	-0,005	0,731
Mg	-0,182	0,487	0,597
Tp	-0,122	-0,255	-0,566

The TABLE IV illustrates the degree of contribution of the eleven physicochemical variables in the inertia of the axes C1, C2 and C3, and the figures 1 and 2 show projection of these variables on the factorial plans "C1xC2" and "C1xC3 ". Similarly, Figures 4 and 5 show the projection of the samples taken in the factorial plans C1xC2 and C1xC3.

Figure 1 shows that all the studied variables are involved in the formation of one or the other of the first three factorial axes, and the analysis of correlations between variables and the factorial axes (TABLE IV) reveals the physicochemical nature of axes:

- Mainly, the C1 axis are positively correlated with calcium hardness (Ca), alkalinity (Alk), pH, Also, it is negatively correlated with the oxidizability and oxygen content. So, this axis corresponds to a gradient of increasing concentration for the three variables and decreasing for the last two variables.
- Only two variables, conductivity (Cd) and the concentration of chloride (Cl), are significantly involved in the formation of the C2 axis. As a result, this axis is considered as an increasing gradient of the salinity.
- Three variables contribute positively to the formation of the C3 axis: the concentrations of the nitrites, nitrates and magnesium (Mg); also, a fourth variable, the temperature (Tp), contributes negatively in this axis. As a result, the axis C3 corresponds an increasing gradient for the three first variables, and a decreasing gradient for the fourth variable.

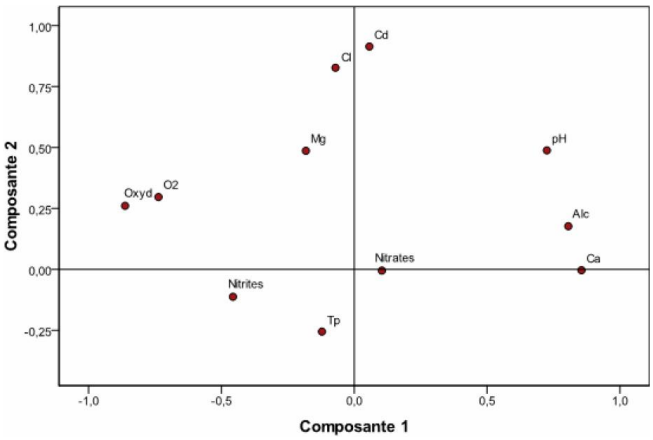

Figure 1 : Projection of the variables in the factorial plan C1xC2

Analysis of factorial designs C1 × C2 and C1 × C3

Projection of points representing the harvesting stations in factorial designs and C1xC2 C1xC3

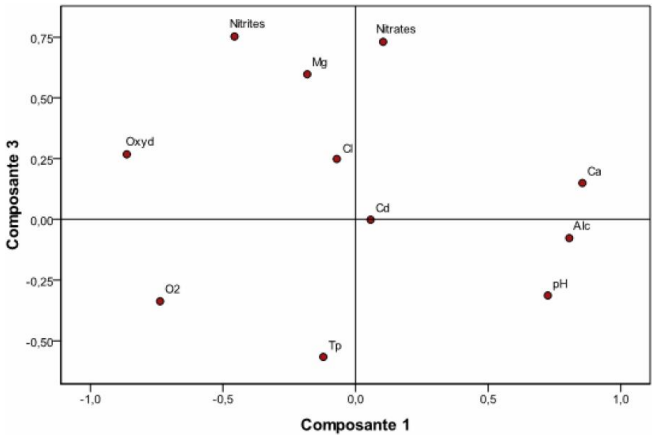

Figure 2: Projection of the variables in the factorial plan C1xC3

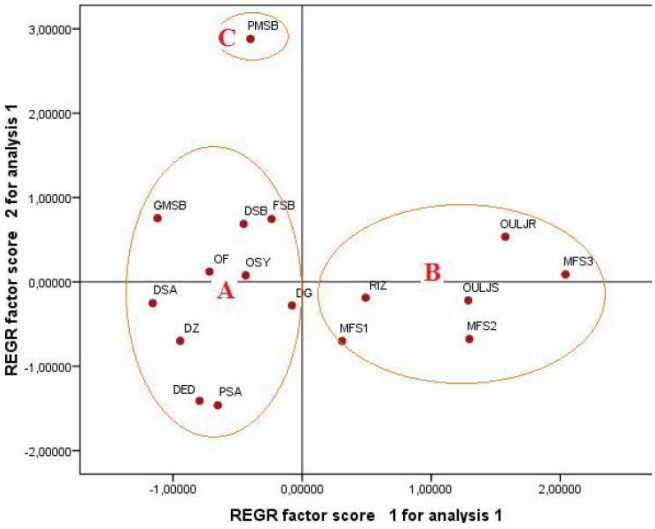

Figure 3 : Projection of points representing the physicochemical characteristics of the habitats in the factorial plan C1xC2

The figure 3 shows a distinction of three groups of samples A, B and C. According to the physicochemical meaning axes C1 and C2, each of the groups is characterized by:

Groupe A: The sample water is characterized by a high oxidizability and high oxygen content; the alkalinity and the concentration of calcium are low. We cite the samples conducted in the large merja, the daya or in the ditch Sidi Bou Ghaba which, respectively, are symbolized by GMSB, DSB and FSB. Adding that, in the same group there are some samples which have a conductivity and chloride concentration that are slightly higher such as those made in dayet Eddis (DED) or in the well of Sidi Amira (PSA).

Grouping B: The samples of water have a lower

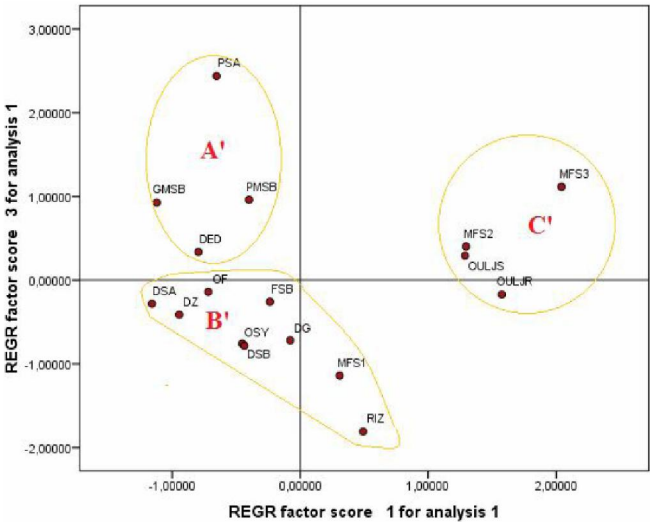

Figure 4 : Projection of points representing the physicochemical characteristics of the habitats in the factorial plan C1xC3

oxidizability and a low dissolved oxygen concentration; the calcium contents are high, but the alkalinity and the concentrations in the chloride and the conductivity are medium.

Grouping C: There is only one sample that was made in the small Merja Sidi Bou Ghaba (PMSB); it is characterized by high chloride content and a high conductivity.

The factorial plane C1xC2 (Figure 4) shows a distinction of three groups of species A ‘, B’ and C ‘. According to the physicochemical meaning axes C1 and C3 each one is characterized by:

Grouping A ‘: In the water of the prospected habitats, the concentration of nitrites, nitrates, and magnesium are medium or high.

Grouping B ‘: in the water of the prospected biotopes, the concentration of nitrites and nitrates, magnesium are lower than those in water biotopes of grouping A’.

Moreover, it should be noted that there is no big difference between the water biotops of the group A’ and the water of the group B’ against the values of the oxidizability, the concentrations of dissolved oxygen, of calcium and of magnesium.

Grouping C ‘: Water of the biotopes is characterized by medium values of temperature, nitrites and nitrates, and magnesium. But, the oxidizability and the concentration of dissolved oxygen are low; the calcium concentration and alkalinity are high.

Projection points representing the harvested species in factorial designs and C1xC2 C1xC3

The plane C1xC2 (Figure 5) shows a distinction of three groups of species A, B and C. According to the physicochemical meaning of the axes C1 and C2 each group is characterized by:

Grouping A : it groups *Ochlerotatus caspius*, *Ochlerotatus detritus*, *Uranotaenia balfouri*, *Culiceta subochrea*, *Culex modestus* and *Uranotaenia unguilata*. According to the physicochemical meaning of factorial axes C1 and C2, water of the larvae biotops of these species has the medium values or slightly higher values of oxidizability and of dissolved oxygen; the alkalinity and the concentration of the calcium, and the pH are slightly low to medium. In addition,the water environments of *Ochlerotatus caspius* and *Ochlerotatus detritus* have a high conductivity and high chloride content.

Grouping B: it is constituted by *Culex hortensis*, *Culex theileri*, *Anopneles labranchiae* and *Culex pipiens*. According to the physicochemical meaning of factorial axes C1 and C2, the water environments of these species is characterized by a high degree of oxidizability, a high dissolved oxygen content, a high concentration of calcium, a high alkalinity, and a high pH. But, the chloride concentration and conductivity are slightly weaker.

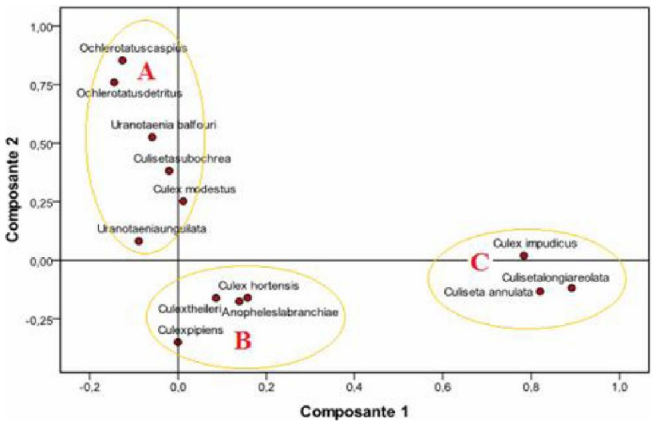

Figure 5 : Projection of the points representing the species in the factorial plan C1xC2

Grouping C: it groups *Culex impudicus*, *Culiseta annulata* and *Culiceta longeriolata*. The water biotopes of the larvae of these three species have a low oxidizability and a low oxygen concentration; the calcium content, the alkalinity and the pH are high. The

conductivity and the chloride content are medium.

Moreover, the projection of the species in the factorial plan C1xC3 (Fig. 6) shows a distinction between three species groupings A ', B' and C '. According to the physicochemical significance of the axes C1 and C3 each one is characterized by:

Grouping A' : it groups *Uranotaenia unguilata*, *Culiceta subochrea*, *Ochlerotatus detritus*, *Culex pipiens* and *Ochlerotatus caspius*. The harvest water environments of these species are characterized by an oxidizability and a concentration of the dissolved oxygen which are medium or slightly higher; the calcium concentration, the alkalinity, and the pH are slightly low; the concentrations of the nitrates, of the nitrites and of the magnesium are medium to high; the temperature is relatively low.

Grouping B ': It groups *Culex hortensis*, *Anopneles labranchiae*, *Culex modestus*, *Culex theileri* and *Uranotaenia balfouri*. The water environment of the harvest of these species is characterized by an average oxidizability and a concentration of the dissolved oxygen which is medium to slightly low. The concentrations of calcium, the alkalinity, and the pH are medium; the concentrations of nitrate, nitrite and magnesium are low to medium, the temperature is medium to high.

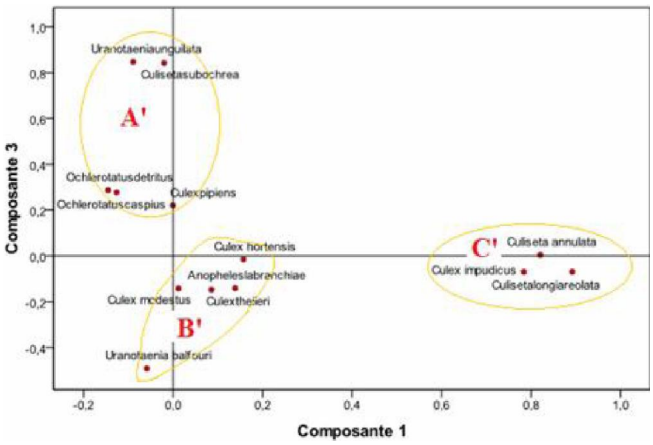

Figure 6 : Projection of the points representing the species in the factorial plan C1xC3

Grouping C ': it is formed by *Culiceta annulata*, *Culex impudicus* and *Culiseta longeriolata*. Their aquatic environments are characterized by a low oxidizability and a low dissolved oxygen concentration; the calcium content, alkalinity and the pH are high; the temperatures and the values for nitrate, nitrite, and magnesium are medium.

Moreover, many ecological data have been reported in previous work about harvested species, *Ochlerotatus caspius* is very common in the coastal plains of Morocco[17]. Its larvae live in water accumulations that have a rich vegetable coverage[18] and which are rich in plant debris[19]; also, its abounds in water having about 29.8 g / l of chlorides[20].

The abundance of the larvae of *Ochlerotatus detritus* is related to the rate of recovery of habitat by halophytic plant species[21-22]; a salinity of 29.8 g / l is very favorable to its growth[23]. In addition, the water of habitats of larvae of *Ochlerotatus caspius*, and *Ochlerotatus detritus* has a high conductivity and a high chloride content.

So, for these first two species, the salinity of the water seems to be a determining factor in their geographical distribution.

According Himmi et *al.*[17], *Uranotaenia balfouri* has an optimum development in water having high hydrogen and low levels of mineralization. This is an Afrotropical species that is present in Morocco in the North Atlantic plains and it is suspected of transmitting some virus to amphibians[24]. Its larvae bites birds and amphibians in permanent or temporary aquatic environments, in fresh or brackish water but which are rich in vegetation[17].

Culiceta subochrea is a species having a wide ecological valence preferring clear water to slightly acidic pH and low levels of salinity[25].

According Mohrig[26], the *Culex modestus* generally live in lakes and ponds with fresh water[27]. The water pH of its habitats has been often acid[26-28]. Note, moreover, that this species is the primary vector of West Nile virus (WNV) in Europe.

According to Schaffner[29], *Uranotaenia unguilata* is a species whose larvae live in freshwater or brackish, slightly sunny or lightly shaded[29,30]. It thrives in shallow marsh grasses, temporary ponds, ditches of irrigation or water accumulations overgrown by lush vegetation and rich in organic matter and duckweed.

Culex hortensis is a species that does not sting humans; it has the adults which hibernate[31]. The larvae live in rural and urban environments and could grow in small areas with fresh, clean water or large

surfaces (canals, ponds) rich in vegetation.

Culex theileri is common in Morocco and develops with high densities[9]. Environmental temperature influences the hatchability of its eggs and a temperature of 36 ° C seems to be very favorable[32]. It is a pest to humans by its bites but in South Africa, it has been found naturally infected with West Nile virus.

Anopneles labranchiae is a species of water accumulations exposed to sunlight[33], temporary or permanent but not exceeding 1900 m altitude[34]. The water of its biotops is shallow, fresh or slightly brackish[35,36], weakly mineralized and covered by a cover vegetable rich in filamentous algae[37-38]. *Anopheles labranchiae* is the major vector of malaria in the Maghreb, particularly in Morocco[34].

Culex pipiens is common in Morocco. It bites humans and has a wide ecological valence[39-41]. The larvae thrive in the stations having low or high temperature, in different pH and low concentration of dissolved oxygen; but, it does not tolerate high salinity or a high mineralization of water[34]. However, the larvae can live even in polluted environments[42].

Culex impudicus larvae abound in accumulations having clear water, cool and shady but can be found in various environments; it grows in environments with low mineralization, with significant water depth and high average temperatures[43]. *Culex impudicus*, being partly ornithophilic, could transmit, during the spring, WNV from migratory birds to non-migratory ones[42].

According Himmi et al. (1995)[34] *Culiseta longeriolata* is a species having a wide ecological valence. It could grow in fresh or brackish water, temporary or semi-permanent and even in polluted waters. In Morocco, it has a great development in low-mineralized waters[34].

According Himmi et *al*. and Trari[17-44] the larvae of *Culiceta annulata* abound in a variety of biotops, natural or artificial, and even polluted, but it is very common in nitrogen-rich waters. The females bite all warm-blooded vertebrates but with a preference for birds and it may transmit the virus myxomatosis.

CONCLUSION

According to the physicochemical conditions in the different biotops, three categories of group of species A, B and C were distinguished:

Category A: It groups *Ochlerotatus caspius*, *Ochlerotatus detritus*, *Uranotaenia unguilata*, *Culiceta subochrea* and *Culex pipiens*. The living environment of the larvae of these species is characterized by: the value of the oxidation in the water and the concentration of dissolved oxygen are high, but the concentration of the calcium and alkalinity level are low, the concentrations of nitrate, nitrite and magnesium are moderate to high, and the temperature is relatively low.

Category B: grouping of *Culex hortensis*, *Culex theileri*, *Anopneles labranchiae* and *Culex pipiens*. The living environment of the larvae of these species is characterized by an oxidizability and a concentration of dissolved oxygen slightly lower than of the environment of the A category species; also, the concentration of calcium, the pH and alkalinity are slightly higher, the chloride concentration and conductivity are slightly weaker, and the concentrations of nitrite, nitrate and magnesium are slightly lower but the temperature is high.

Category C: It includes *Culiceta annulata, Culex impudicus* and *Culiseta longeriolata*. The living environment of the larvae is characterized by low levels of dissolved oxygen and the low oxidizability but the content of calcium, alkalinity and pH are high; the temperature values and the concentrations of nitrates and nitrites are average; also, the concentrations of the magnesium and the chloride and conductivity value are medium.

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