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Diversity and distribution of culicinae fauna in Tebessa district (North-East of Algeria)

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Abstract
Mosquito monitoring has been conducted in the Tebessa district with the aim of gaining information about Culicidian species composition, biodiversity and spatio-temporal distribution. The results were based on all sampled mosquito breeding sites found randomly in the four selected locations. The systematic study revealed the presence of 10 species belonging to 3 genera; *Culex, Culesita* and *Aedes*. *Culex* genus was the predominant taxa, with record of 8 species; *Culex pipiens, Culex pipiens molestus, Culex modestus, Culex theileri, Culex univittatus, Culex perexiguus, Culex hortensis* and *Culex laticinctus*. The other genera were represented by 1 species each; *Culiseta longiareolata* and *Aedes aegypti*. *Culiseta longiareolata, Culex pipiens* were abundantly distributed during the all year. Whereas the other species their temporal distribution was depending to the high temperature and type of breeding habitats. Monitoring the temporal and spatial distribution of mosquitoes is an essential step in the risk analysis of emerging mosquito-borne diseases.

Keywords: Diversity, distribution, culicidae, mosquito

1. Introduction
Mosquitoes are distributed throughout the world and have occupied many biotopes. They differ in their development habitats which vary from species to species and also in the mode or time of biting [1]. The development period from egg to adult varies among species and is strongly influenced by ambient temperature. Effect of natural factors like temperature, humidity and rain fall also have a positive impact on the proliferation of mosquitoes. Therefore the climate has been established as an important determinant in the distribution of vectors and pathogens [2]. Monitoring pathogen vectors becomes a necessary step in making up of disease surveillance and control programs.
It has been reported that several mosquitoes belonging to the genera *Anopheles, Culex* and *Aedes* are vectors for pathogens of various diseases such as malaria, filariasis, yellow fever, dengue, Japanese Encephalitis (JE) and hemorrhagic fever [3]. Malaria and lymphatic filariasis are two of the most common mosquito borne parasitic diseases worldwide which can occur as concomitant human infections while also sharing common mosquito vectors [4]. Filarial parasites affect over 120 million people in many endemic countries worldwide, located throughout tropical and subtropical regions of South America, Asia and Africa [5]. Even when mosquitoes do not transmit disease, they may cause great annoyance, making areas originally suitable for human and animal occupation quite uninhabitable. Vector borne diseases are worldwide and exert enormous burden on the continent of Africa [6].
The seasonal variations directly affect the growth, development and activities of mosquito species and remain present as long as water supply remains constant [7] then in wet season the larval indices found to be greater as compared to the dry season [8]. The dynamics of seasonal population of mosquito species was related to climatic factors as well as human activities by creating artificial water recipients. Environmental degradation, mainly by the process of urbanization, increase the sites for mosquito proliferation, consequently cause a serious public health, since vectors and a potential pathogens may adapt to exploit new ecological niches, unless strict environmental control measures are enforced [9].
Only female mosquito sucks the blood which is required for its oviposition. These species present in abundance are influenced by the female behavior of oviposition, as well as their temporal space distribution, which has predominant dependency on the environment and the local climate in which they occur, with female mosquitoes searching for conditions favorable to survival of progeny [10]. Hence, the present study was focused to survey and to provide new

insights about the diversity and spatio-temporal distribution of mosquito species in a semi-arid region, the Tebessa district.

2. Materials and methods

2.1 Study area and sampling sites

The study areas are represented by the district of Tebessa. It is located in the North-Eastern part of Algeria belonging to the tellian plaines (8°50' to 7°25'E; 34°75'to 36° N) with a surface of 13878 km² and an altitude of 956m of the sea level. This region is characterized by a dry climate, hot and dry summer and humid and soft winter and the main parts of the region have a tendency to be arid semi-arid. The study sites were conducted in selected urban, sub-rural and rural areas of the Tebessa district. They are represented by 4 locations; Tebessa, Ouenza, Morsott and El-Meridj, covering the district area.

2.2 Specimen collection

The mosquito collection was carried out at each site, at regular interval times with 2 sampling process per month during the study period (June 2011- May 2012). Adult mosquitoes were collected with the help of oral aspirators from building caves and houses beside the proliferation sites. Apart from this, catches in outdoor shelters like gardens and wild vegetation were also made during day time. Pertinent collection details were recorded in the field for each collected specimen. In the laboratory these specimens were preserved in collection cages containing dates and water jar. For each collection specimens were subjected to quantitative and qualitative investigations.

Larval collection was done by using standard entomological dipping technique for the collection of the immature stages from the different breeding sites which provide suitable breeding places for mosquitoes around the year. The immature stages brought from the field were separated to the different larval stages and reared in the laboratory until adult emergence. The systematic study was carried out by the dissection of adults. The different parts of the insect were separated; head, thorax and abdomen extremity, where the main criteria of identification are located. Whereas some species there genitalia should to be examined in order to be identify. The identification of mosquito species was made according the morphological parameters described previously [11, 12] with the use of two logiciel editions [13, 14]. This was carried out on microscopic observations of slides prepared for the subject [15].

2.3 Data Analyses

The mosquito adult populations collected from the different study sites of the area were subjected to some analyses using ecological indices.

2.3.1 Relative Abundance (RA %): The dominance of the mosquito species for each site was estimated by the relative abundance (*RA%*). This was expressed by the ratio between number of specimens of a species and the total number of specimens of all mosquito species caught in the site ×100.

2.3.2 Pattern of occurrence (C%): The knowledge on the distribution pattern of mosquitoes reveals the dimension of spatial distribution in the selected study area. The distribution of mosquito species was estimated using the pattern of occurrence (C %), according to the method adopted by Rydzanicz & Lonc [16], using the following formula: $C = n/N \times 100$. Where n = number of sites positive for the occurrence of mosquitoes and N = total number of sites studied. According to occurrence value mosquito species were classified into 5 categories: If $C = 0–20\%$ the distribution pattern of the species is sporadic, $C = 20.1–40\%$ the distribution pattern of the species is infrequent, $C = 40.1–60\%$ the distribution pattern of the species is moderate, $C = 60.1–80\%$ the distribution pattern of the species is frequent and $C = 80.1–100\%$ the distribution pattern of the species is constant.

2.3.3 The specific diversity: The biodiversity of the study sites was evaluated by the Index of Simpson's diversity (*IS*). This reveals the relationship between the number of species and the number of specimens at the same time. It was calculated according to the following formula: $IS = 1/(\Sigma Pi2)$. Pi is the proportion (P) of the species (i) in a study site ($Pi = RA/100$).

2.3.4 The distribution: In order to estimate the distribution of mosquito population in the study sites the Equitability (*E*) was calculated by the use of the following formula ($E = (IS–1)/(SR–1)$). (*SR*) is the specific richness of species and was estimated by the total number of each species per site [17].

3. Results

The collection survey of mosquitoes was conducted, in four sites located in Tebessa district; Ouenza, Morsott and El-Meridj, in order to study the mosquito diversity, distribution and abundance during the period of June 2011- May 2012. This survey yielded to the collect of 4191 mosquito adults representatives of 10 species belonging to 3 genera; *Culex, Culiseta* and *Aedes*. Out of these genera, genus *Culex* was found to be the predominant taxa, with record of 8 species; *Culex pipiens, Culex pipiens molestus, Culex modestus, Culex theileri, Culex univittatus, Culex perexiguus, Culex hortensis* and *Culex laticinctus* (Table 1). This was followed by *Culiseta* with 1 species; *Culiseta longiareolata* and *Aedes* was represented too by a single species *Aedes aegypti.* It was observed that all these species exploit differently the habitats.

The dominance of the mosquito species for each site was estimated by the relative abundance (RA %) and is presented in table 1. The results showed that *Culex pipiens* and *Culiseta longiareolata* were the most abundant and dominant species recorded in the study sites. It was noticed that the *Culex pipiens* was more abundant than *Culiseta longiareolata* in 3 sites with RA% of 35.86 in Tebessa, 36.06 in Ouenza and 30.44 in Morsott. Therefore the RH% of *Culiseta longiareolata* was 25.87 in Tebessa, 26.29 in Ouenza and 27 in Morsott but the RH% was higher in El-Meridj with a value of 35.67. The other species their abundance was moderate and varies from site to another and depending to the season. The diversity study showed the presence of the 8 identified species only in the Ouenza Site. The 3 other sites some species were completely absent; such as *Culex theileri* and *Culex laticinctus* were not recorded in Tebessa. In Morsott 3 *Culex* species were not found; *Culex pipiens molestus, Culex univittatus* and *Culex perexiguus.* In El-Meridj sit only *Culex theileri* was absent.

Table 1: Diversity and abundance (RA%) of mosquito species recorded in the different study sites, during the study period (June 2011- May 2012).

Species	Abundance (RA%) of mosquito species/sites			
	Tebessa	Ouenza	Morsott	El-Meridj
Culex pipiens	35.86	36.06	54	30.44
Culiseta longiareolata	25.87	26.29	27	35.67
Culex pipiens molestus	5.67	4.91	-	0.54
Culex modestus	14.55	5.90	9.50	6.81
Culex theileri	-	3.60	1.52	-
Culex univittatus	3.54	2.95	-	6.53
Aedes aegypti	4.96	4.91	3.04	2.17
Culex perexiguus	4.25	7.86	-	3.81
Culex hortensis	5.30	4.91	3.42	10.15
Culex laticinctus	-	2.61	1.52	3.88

To know the distribution of mosquito, the pattern of occurrence was estimated for all the study areas (Table 2). *Culiseta longiareolata* was the most dominant species with C=44.45%, therefore it was considered moderate. The pattern of occurrence (C = 30.54%) *Culex pipiens* was frequently distributed during the study period. Therefore the remaining species; *Culex pipiens molestus, Culex modestus, Culex theileri, Culex univittatus, Aedes aegypti, Culex perexiguus, Culex hortensis* and *Culex laticinctus*, their pattern of occurrence were less than 20%, consequently their distributions were sporadic.

Table 2: The pattern of occurrence of mosquito species collected in the study area during the study period (June 2011- May 2012).

Species	Adult number	RA (%)	Occurrence	N° species
Culiseta longiareolata	1863	44.45	moderate	1 species
Culex pipiens	1280	30.54	infrequent	1 species
Culex pipiens molestus	392	9.35	sporadic	8 species
Culex modestus	271	6.46	sporadic	
Culex theileri	172	4.10	sporadic	
Culex univittatus	64	1.52	sporadic	
Aedes aegypti	51	1.21	sporadic	
Culex perexiguus	49	1.16	sporadic	
Culex hortensis	25	0.59	sporadic	
Culex laticinctus	24	0.57	sporadic	
Total	4191	100		

The study has been carried out during the four seasons in which 2 species, *Culiseta longiareolata, Culex pipiens* were predominantly distributed during the all year (Table 3). Whereas during the hot period, that covering spring, summer and autumn seasons four species; *Culex pipiens molestus, Culex modestus, Culex theileri* and *Culex univittatus*, were recorded present in study the area. Whereas the other four species; *Aedes aegypti, Culex perexiguus, Culex hortensis* and *Culex laticinctus,* their temporal distribution were depending to the high temperature of the summer period.

Table 3: Temporal distribution of the mosquito species recorded in the study area during the study period (June 2011-May 2012)

Species	Summer			Autumn			Winter			Spring		
	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Culiseta longiareolata	+	+	+	+	+	+	+	+	+	+	+	+
Culex pipiens	+	+	+	+	+	+	+	+	+	+	+	+
Culex pipiens molestus	+	+	+	+	+	+	+	-	-	+	+	+
Culex modestus	+	+	+	+	+	-	-	-	-	-	+	+
Culex theileri	+	+	+	+	+	+	-	-	-	-	+	+
Culex univittatus	+	+	+	+	+	+	+	-	-	-	+	+
Aedes aegypti	+	+	+	-	-	-	-	-	-	-	+	+
Culex perexiguus	+	+	+	+	+	+	-	-	-	-	-	-
Culex hortensis	+	+	+	+	-	-	-	-	-	-	-	+
Culex laticinctus	+	+	+	-	-	-	-	-	-	-	-	-
Total number of species	10	10	9	8	7	6	4	2	2	3	7	8

The diversity indexes mosquito species showed an evolution, more the specific richness (SR) increases the diversity progresses. These indexes are high practically in all study sites (figure1), in all the study sites. These traduce the stability of the medium, where the species share well the life medium.

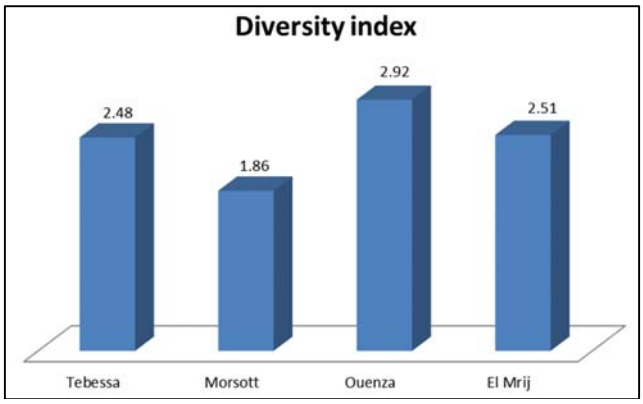

Fig 1: diversity index (*IS*) of mosquito species in the study areas.

The climate factors are determining for the presence and proliferation of mosquito species instead of their type of breading habitats. In the area of the present study, temperature and rainfall are influencing the density and the distribution of mosquito. The average of the maximum temperatures during the period study were varying between 36.4 °C in hot period; the summer and 9.2 °C the cold period the winter. This fluctuation in temperatures between seasons could explain the absence of some species mentioned in table 3, during the winter and the spring seasons. The temperatures also stimulate the mosquito distribution and increase the abundance with high degrees that recorded mainly during the hot summer and autumn (Table 4). During the four seasons the study area had a round of 30 mm of rainfall and this supply the natural breeding habitats with water. This could be correlated to the mosquito presence through all the seasons.

Table 4: The average of the temperature and the rainfall of Tebessa district during the study period (2011-2012).

Month	Season	Max. °C	Min. °C	Rainfall (mm)	Average Rainfall (mm)
June	summer	30.6	14.0	29.0	31.66
July		36.4	18.6	55.0	
August		35.7	18.2	11.0	
September	autumn	31.3	15.6	3.0	31.0
October		22.4	9.8	87.0	
November		17.8	7.2	3.0	
December	winter	13.5	2.7	7.0	32.66
January		11.5	1.4	36.0	
February		9.2	0.3	55.0	
March	spring	15.4	4.1	39.0	30.33
April		21.4	7.2	25.0	
May		28.4	10.4	27.0	

4. Discussion

Present study was conducted out in order to identify all the species of mosquitoes (Diptera: Culicidae) collected in Tebssa district, to determine their population dynamics in different seasons and to correlate their distribution with the seasonal temperature. The systematic study showed the presences of 10 species belonging to 3 genera; *Culex, Culiseta* and *Aedes*. The group of *Culex* is essentially composed mainly by *Cx pipiens*, near the urban areas, and to a lower degree of *Cx. pipiens molestus, Cx. modestus, Cx. theileri, Cx. univittatus,* and *Cx. perexiguus.* Similar study was done in the Northern region of Aures, Algeria, 4 species of *Culex: Cx. mimeticus, Cx. hortensis, Cx. laticinctus* and *Cx. pipiens,* 3 species of *Anopheles*; *An. labranchiae, An. Hispaniola,* and *An. marteri,* and a single species of *Culiseta*: *Cs. Longiareolata* were recorded [18]. It is also reported the absence of the genus of *Aedes*, in this region but its presence was recorded in the Southern part of the Aures. In the North of Algeria, 27 species of Culicidae were listed in the region of Algiers [19, 20]. While in the West side of the country a number of 20 species of Culicidae were noted [21]. Therefore the mosquito survey conducted in the region of Collo (North-East of Algeria), 30 species belonging to 5 genera were identified [22]. The inside part of the country, in Mila's region (Western side of Constantine) the inventory of mosquitoes reveals the presence of 12 species: 8 of *Culex* species (*Cx. pipiens, Cx. modestus, Cx. antennatus, Cx. hortensis, Cx. deserticola, Cx. theileri, Cx. laticinctus* and *Cx. antennatus*) two of the *Anopheles* species (*An. labranchiae* and *An. pharoensis*), one of the *Culiseta* species (*Cs. longiareolata*) and a single species of *Uranotaenia* (*Ur. unguiculata*) [23]. A systematic study of Culicidae at the region of Tébessa made during the period 2006-2007 revealed the presence of 9 species belonging to 3 genera: *Culex, Culiseta* and *Aedes*. 5 species of *Culex: Cx. pipiens, Cx. theileri, Cx. hortensis, Cx. perexiguus* and *Cx. laticinctus.* The genus of *Culiseta* was represented with 3 species: *Cs. longiareolata, Cs. annulata* and *Cs. subochrea*. While the *Ochlerotatus* species only the *Ochlerotatus caspius* was found [24]. The variation in the mosquito diversity from region to other depends on the type of region and the climate. Mosquitoes differ in their habitats and their period of development, from egg to adult, varies among species and is strongly influenced by ambient temperature. The climatic factors, temperatures and rainfall, and chemical composition of the water, are the most important elements for the development and the distribution of the culicinae fauna [23], even so the temperature remains essential factor for the accentuation of the development speed of the mosquito. The physico-chemical parameters revealed an effect on the fluctuation in the larval stages of mosquitoes in particular *Culiseta longiareolata* and *Culex pipiens* [25].

The spatio-temporal results showed that the *Culex pipiens* was distributed over the all year and this concord with a previous work [25]. This fact could be explained by the global warming translated into North Africa by a soft winter [26]. The ecological analysis of the results such as the relative abundance reveals that *Culiseta longiareolata* was the most distributed species followed by *Culex pipiens*. It was reported

that *Culex pipiens* and *Culiseta longiareolata* species were very widely distributed at the Mediterranean African countries [20]. This was confirmed by a previous works, reporting the abundance and the dominance of these two species [23, 24].

The spatio-temporal distribution of *Aedes caspius* presents a correlation with the vegetation in the breading habitats, constituting an organic matter essential to the development of the immature stages. While the maximum species density was observed in a temperature ranging from 20 to 27.7 °C and an alkaline medium with a PH varies 8 to 9 [27]. The seasonal variations directly affect the growth, development and activities of *Aedes* mosquitoes. In cooler climates *Aedes species* develop in a week up to a month. It can remain in the larval stage for a month as long as water supply remains constant [28]. The eggs of *Aedes* species are desiccation resistant; this factor is of great entomological consideration because even during the dry season the eggs remain viable. *Aedes* species is very much susceptible to the climatic factors and seasonal variation. Some models and analysis had been represented to show the global scale association between climatic factors and development, potential distribution and population dynamics of *Aedes* mosquitoes [29].

The distribution and the density of mosquito species were inconstant, because of during the sampling some species were present with large number of adults while others were found present only with a few ones. Therefore, the difference in the mosquito density in the different study sites was probably due to the phenology of species during the study period and the biotopes and climatic conditions, including temperature, precipitation and wind speed, which play the role of limiting factor for many flying insects [30].

5. Conclusion

The survey of the temporal and spatial distribution of mosquitoes become an integral part for drawing out surveillance programs and control measures. The diversity study and the establishment of the general distribution of mosquitoes are directly implicated in the dynamics of infectious diseases, like malaria. While this result contributes to the existing of these insect vectors in Tebessa region, it is important to consider that seasonal fluctuations of mosquitoes insects which are varied across the year, affecting both the abundance of individual species and the diversity composition, and their subsequent response to climatic variation. Because of drastic ecological changes in this region, mainly by the urbanization, the Culicinae fauna has altogether changed. It is recommended that intensive and extensive surveys have to be carried out in rest of the country in order to be used by public health authorities for taking preventive measures against the outbreak of the vector borne diseases.

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