

Inventory and Distribution of Mosquitoes (Diptera, Culicidae) in the Aures Region (Batna, Algeria)

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Cover Page Footnote

We would like to express our gratitude to the members of the research laboratory of Mohamed Boudiaf University M'Sila, particularly Dr. Benhissen who helped us during the execution and writing of this work.

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INVENTORY AND DISTRIBUTION OF MOSQUITOES (DIPTERA, CULICIDAE) IN THE AURES REGION (BATNA, ALGERIA)

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ABSTRACT

Mosquitoes are the most terrifying both for their abundance and for the diseases they transmit. They are vectors of malaria, lymphatic filariasis and arbovirus such as yellow fever, dengue, viral encephalitis and African horse sickness. These characteristics give this fauna prominent importance and health interest. To identify the most widespread mosquito species, we conducted for the first time an inventory in the Aures region more particularly the wilaya of Batna (East of Algeria) from May 2017 to January 2020, we studied their diversity, abundance and distribution. The sampling is done by monthly surveys of the various localities chosen, using the dipping method to collect the larvae. In the various sites prospected, we were able to collect a total of 8275 mosquito individuals presented by nine species belonging to four different genera: *Culiseta*, *Culex*, *Aedes* and *Anopheles* of which the genus *Culiseta* is the best represented, particularly with the species *Culiseta longiareolata* (52.07%). It appears from what we have obtained that the Batna region reveals a significant diversity of mosquitoes. This study aimed to inventory the Culicidian species more broadly by surveys in several localities of Batna region at the level of different environments. This will allow us to know the faunistic composition of the region, to collect and record information on the vectors, their habitats and the conditions that favors their multiplication within a given area

KEYWORDS: Inventory, diversity, Culicidae, Batna region, mosquitoes

INTRODUCTION

Many arthropods can transmit disease. Among these, Mosquitoes are the most terrifying both for their abundance and for the diseases they transmit. They are vectors of malaria, lymphatic filariasis and arbovirus such as yellow fever, dengue, viral encephalitis (Coosemans and Van Gompel, 1998) and African horse sickness (Rioux, 1958). These characteristics give this fauna

prominent importance and health interest (Louah et al., 1995).

The fauna of Culicidae is distributed in the Mediterranean regions, in America, India, Northern Europe, Mediterranean Europe, Asia and Madagascar (Senevet and Andarelli, 1963). In Algeria, 50 species of Culicidae of 6 different genera are grouped in the subfamilies of Anophelinae and Culicinae (Hassaine, 2002).

The most effective approach to mosquito control remains that based on the elimination or reduction of mosquito breeding sites, because at this stage mosquitoes occupy minimal geographical space and are easily located and controlled, this control must be adapted to the following factors: the correct identification of the species, the knowledge of their breeding sites, their behaviour and their ecology that is fundamental to ensure the effectiveness of this action (Djogbénou, 2009).

Investigations made on Culicidae are related to their bioecology in Constantine (Berchi, 2000), in Tlemcen (Hassaine, 2002), in Algiers and Tizi Ouzou (Lounaci, 2003), (Bebba, 2004) in the region of Oued-Righ, (Berrezig, 2007; Aouati, 2009 and Tahraoui, 2012) in the region of El-Kala, (Hamaidia, 2004) in the regions of Souk-Ahras and Tebessa, (Benhissen, 2016) in the region of Ouled Djelal, (Merabti et al., 2017) in the Biskra region as well as (Benhissen et al., 2018) in the Bousaâda region.

The present study aims to inventory the Culicidian species more broadly by surveys in several localities of Batna region at the level of different environments. This will allow us to know the faunistic composition of the region, to collect and record information on the vectors, their habitats and the conditions that favors their multiplication within a given area.

MATERIAL AND METHODS

Presentation of the Study Region

The study was conducted in the Batna region, which is located in the north-east of Algeria, in the Aures region. It is located 410 km from Algiers and rises to more than 900 m from sea level. It is

bounded in the North by the Wilaya of Mila, in the North-East by the Wilaya of Oum El Bouaghi, in the East by the Wilaya of Khenchela, in the South by the Wilaya of Biskra, in the West by the Wilaya of M'Sila and in the North-West by the Wilaya of Setif (DRC, 2017). It covers an area of 12,038.76 km². Batna, the chief - place of the Wilaya is 425 km East of the capital, it has 21 dairas and 61 communes (Aures, 2013) (Figure 1).

Survey Sites

This study took place from May 2017 to January 2020, either over a period of 24 months. It focused on a sample of 4 sites, selected on different criteria.

They were mainly: wells, ponds, and basins (Table 1).

- S1 (Dhara Aissi): This is an open cement basin within a new nursery project that serves to store irrigation water. This basin has an area of 20 m² and a depth of 1.5 m.
- S2 (Forum Toub): The selected site is a traditional well located in an abandoned apple orchard. The well is characterized by the presence of plant debris and the bad smell of water.
- S3 (Forage Parc): A waterhole with a very polluted watercolor from green to black and a bad smell. The vegetation cover is present in the middle and on the edge of the site and consists of weeds and some algae.
- S4 (Timgad): The selected site is a permanent pond which is located in a wadi, it is embraced and the water is clear with the presence of vegetation.

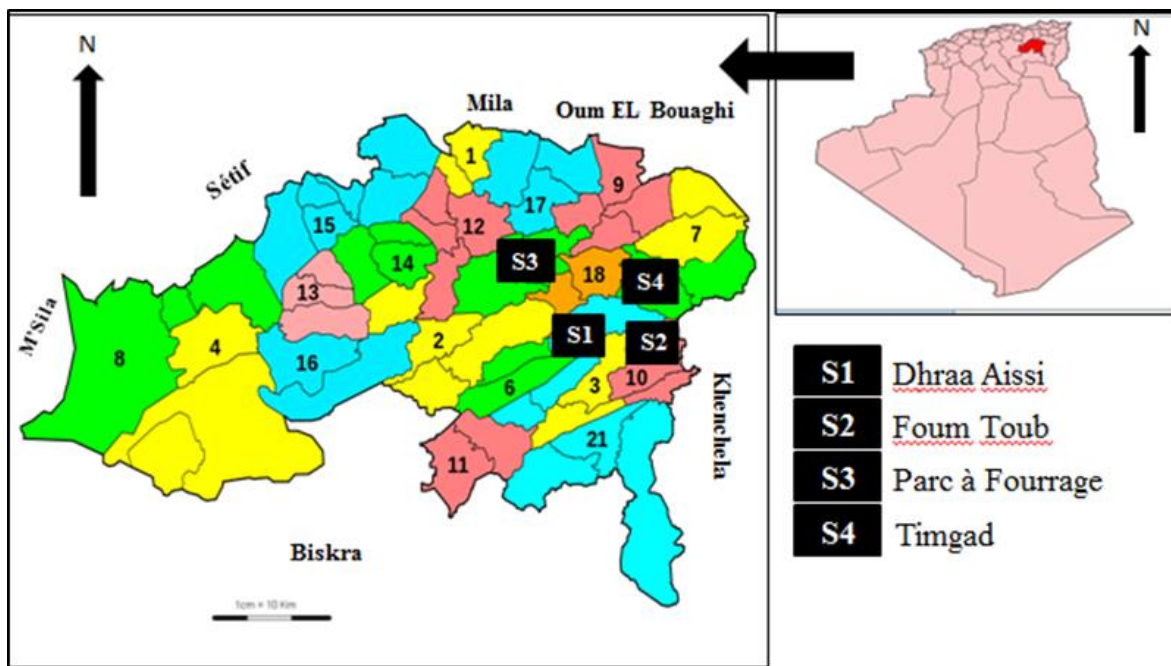


Figure 1: Geographic location of the study sites (ANIREF, 2011).

Table 1: Main characteristics of the sites selected in the Batna region

Sites	Latitude (N)	Longitude (E)	Environment	Character	Nature	Water
(S1)	35°46'63,59"N	6°31'70,44"E	Urban	Basin	Permanent	W
(S2)	35°41'52,44"N	6°58'64,83"E	Rural	Well	Permanent	W
(S3)	35°54'10,97"N	6°18'59,13"E	Urban	Mare	Permanent	Rn/R
(S4)	35°49'72,35"N	6°46'58,82"E	Rural	Mare	Permanent	Rn/R

(S1: Dhraa; S2: Forum Toub; S3: Forage parc; S4: Timgad; W: Wells, R: Rolling, Rn: Rain).

Sampling Technique and Identification

The sampling of larvae was done using the dipping method. This method consists of dipping, in several places of the larval site, a dipper containing a container of a known capacity (500 ml). For the wells, we used a bucket of a known capacity (5 liters) and a rope.

The generic and specific diagnosis requires the careful observation of the entire body of the larva, the pupa and the adult and particularly the morphological characters of the body of taxonomic importance, which were examined.

We used the identification keys of the larvae proposed by Rioux (1958). The results obtained were also confirmed with the identification software for Culicidae of Mediterranean Africa (Brhunes et al., 1999).

Ecological Index and Statistical Processing of Data

The ecological index that we consider for the exploitation of our results are the relative abundance (F %) Dajoz (1971), the frequency of occurrence (C %) Dajoz (1982), the total richness (Blondel,

1975), the specific diversity H' (Shannon and Weaver, 1949) and the equitability (E) Barbault (1981).

RESULTS

Inventory of Culicidae

The systematic inventory of Culicidae mosquitoes collected in the different study sites, revealed after identification the presence of nine species belonging to two subfamilies: Anophelinae and Culicinae (Table 2).

The subfamily Culicinae appeared to be the richest in species, it is divided into three genera: the genus *Culex* with four species (*Culex pipiens*, *Culex theileri*, *Culex hortensis* and *Culex deserticola*), the genus *Culiseta* represented by two species (*Culiseta longiareolata* and *Culiseta subochrea*) and the genus *Aedes* with only one species *Aedes caspius* and the subfamily Anophelinae is represented by the genus *Anopheles* which includes two species (*Anopheles labranchiae* and *Anopheles cinereus*) (Table 2).

Table 2: List of Culicidae identified in the Batna region during the study period.

Sub family	Genus	Species
Culicinae	<i>Culex</i>	<i>Culex pipiens</i> (Linné, 1758).
		<i>Culex theileri</i> (Théobald, 1903).
		<i>Culex hortensis</i> (Ficalbi, 1889)
		<i>Culex deserticola</i> (Kirkpatrick, 1924).
	<i>Culiseta</i>	<i>Culiseta longiareolata</i> (Aitken, 1954).
		<i>Culiseta subochrea</i> (Edwards, 1921).
	<i>Aedes</i>	<i>Aedes caspius</i> (Pallas, 1771).
Anophelinae	<i>Anopheles</i>	<i>Anopheles labranchiae</i> (Falleroni, 1926).
		<i>Anopheles cinereus</i> (Brunhes et al., 1999).

Distribution of Collected Mosquito Species

The present work, devoted to the realization of a study on the Culicidian fauna of the Batna region, collected from the four sampling sites, a total number of 8275 mosquito individuals of which the species *Culiseta longiareolata* was the most frequent with 4309 individuals followed by *Culex pipiens* with 3385 figure 2 (A).

On the other hand, the number of individuals of the species *Culiseta subochrea*, *Aedes caspius*, *Anopheles labranchiae* and *Anopheles cinereus* did not exceed (7, 1, 2, 1) individuals respectively figure 2 (A).

At Forage Parc *Culex pipiens* was also ranked in the first place in terms of relative abundance 48% followed by *Culiseta longiareolata* with the rate of 36%. *Culex theileri* in third place with a rate of 15.77% while *Culex hortensis* was less present in this site with a rate of 0.19% see figure 3 (C).

In the Timgad site, *Culiseta longiareolata* was the most abundant species with a rate of 66.81% followed by *Culex pipiens* with 15.96% and *Culex hortensis* 9.87% while *Culex deserticola* and *Culex theileri* were present with rates of 3.68% and 3.29% respectively. The other species were not very present on this site with rates varying from 0.16% to 0.05% figure 3(D).

Ecological Analysis of the Culicid Fauna

i. Ecological Composition Index

The results of the relative abundance of Culicidae species encountered in the four sites are represented in figure 3. Only one species was observed in Dhraa Aissi, *Culiseta longiareolata*, with a rate of 100 % in figure 3(A). The relative abundance (%) of species in the Foug Toub site showed that among the five species recorded *Culex pipiens* was the most abundant species with a rate of 68.04 % followed by *Culiseta longiareolata* with 31.26 %. While *Culex hortensis*, *Culex theileri* and *Culiseta subochrea* were not very present in this site with a rate of 0.31 %, 0.25 % and 0.11 % respectively figure 3 (B).

From the results of the frequency of occurrence (C %) revealed by Table 3, we found that *Culiseta longiareolata* was classified as a ubiquitous species with 100% in the site of Dhraa Aissi. Two

categories of species are defined in the site of Foug Toub. Two species collected in this site were considered ubiquitous species; it is essentially *Culex pipiens* and *Culiseta longiareolata*. While *Culex theileri*, *Culex hortensis* and *Culiseta subochrea* were accidental species (Table 3).

Similarly, the results show the existence of four categories of species in the Forage Park area. Only one species collected was considered ubiquitous, *Culiseta longiareolata*, *Culex pipiens* was considered a constant species. One accessory species, (*Culex theileri*), while *Culex hortensis* was considered an incidental species (Table 3).

In Timgad *Culiseta longiareolata* was defined as a constant, *Culex pipiens* as a regular species. Accessory species were *Culex theileri*, *Culex hortensis* and *Culex deserticola*, while incidental species were *Culiseta subochrea*, *Aedes caspius*, *Anopheles labranchiae* and *Anopheles cinereus* (Table 3).

Table 3: Frequency of occurrence and category of mosquito species found in the study sites.

Site Species	Dhraa Aissi		Foug Toub		Forage Parc		Timgad	
	C %	Cate	C %	Cate	C %	Cate	C %	Cate
<i>Cx. pipiens</i>	/	/	100	Omni	95,83	Cons	70,83	Régu
<i>Cx. theileri</i>	/	/	8,33	Acci	29,16	Acce	33,33	Acce
<i>Cx. hortensis</i>	/	/	12,5	Acci	4,16	Acci	29,16	Acce
<i>Cx. deserticola</i>	/	/	/	/	/	/	25	Acce
<i>Cs.longiareolata</i>	100	Omni	100	Omni	100	Omni	95,83	Cons
<i>Cs. subochrea</i>	/	/	8,33	Acci	/	/	4,16	Acci
<i>Ae. caspius</i>	/	/	/	/	/	/	4,16	Acci
<i>An. labranchiae</i>	/	/	/	/	/	/	4,16	Acci
<i>An. cinereus</i>	/	/	/	/	/	/	4,16	Acci

(C %: Frequency of occurrence, Cat: Category, Omni: Omnipresent, Cons: Constant, Regu: Regular, Acce: Accessory, Acci: Accidental).

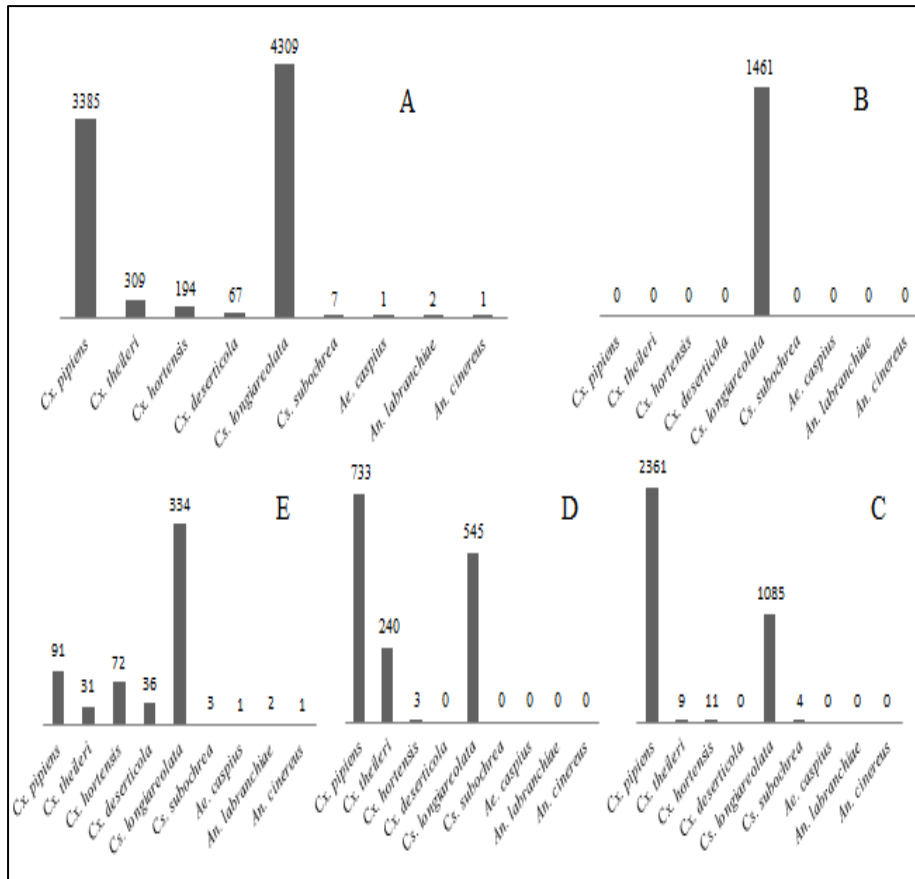


Figure 2: Numbers of culicid species surveyed in the Batna region during the study period.

(A: Total numbers collected in the four study sites, B: Numbers collected in Dhraa Aissi, C: Numbers collected in Foug Touf, D: Numbers collected in Forage Parc and E: Numbers collected in Timgad).

Table 4: Total richness (S), specific diversity (H'), maximum diversity (H'max) and equitability (E) of Culicidae in the 4 study stations

Species	Dhraa Aissi	Foug Touf	Forage Parc	Timgad
<i>Cx. pipiens</i>	/	2361	733	291
<i>Cx. theileri</i>	/	9	240	60
<i>Cx. hortensis</i>	/	11	3	180
<i>Cx. deserticola</i>	/	/	/	67
<i>Cs. longiareolata</i>	1461	1085	545	1218
<i>Cs. subochrea</i>	/	4	/	3
<i>Ae. caspius</i>	/	/	/	1
<i>An. labranchiae</i>	/	/	/	2
<i>An. cinereus</i>	/	/	/	1
Effectif /station	1461	3470	1521	1823
H'/station	0	0,965	1,483	1,532
S/station	1	5	4	9
Hmax/station	0	2,332	2,009	3,184
E/station	0	0,414	0,738	0,481
D	-0,005	0,438	0,612	0,514

S: Total richness, H': Shannon-Weaver index, Hmax: Maximum diversity, E: Equitability index (evenness index) and D: Diversity).

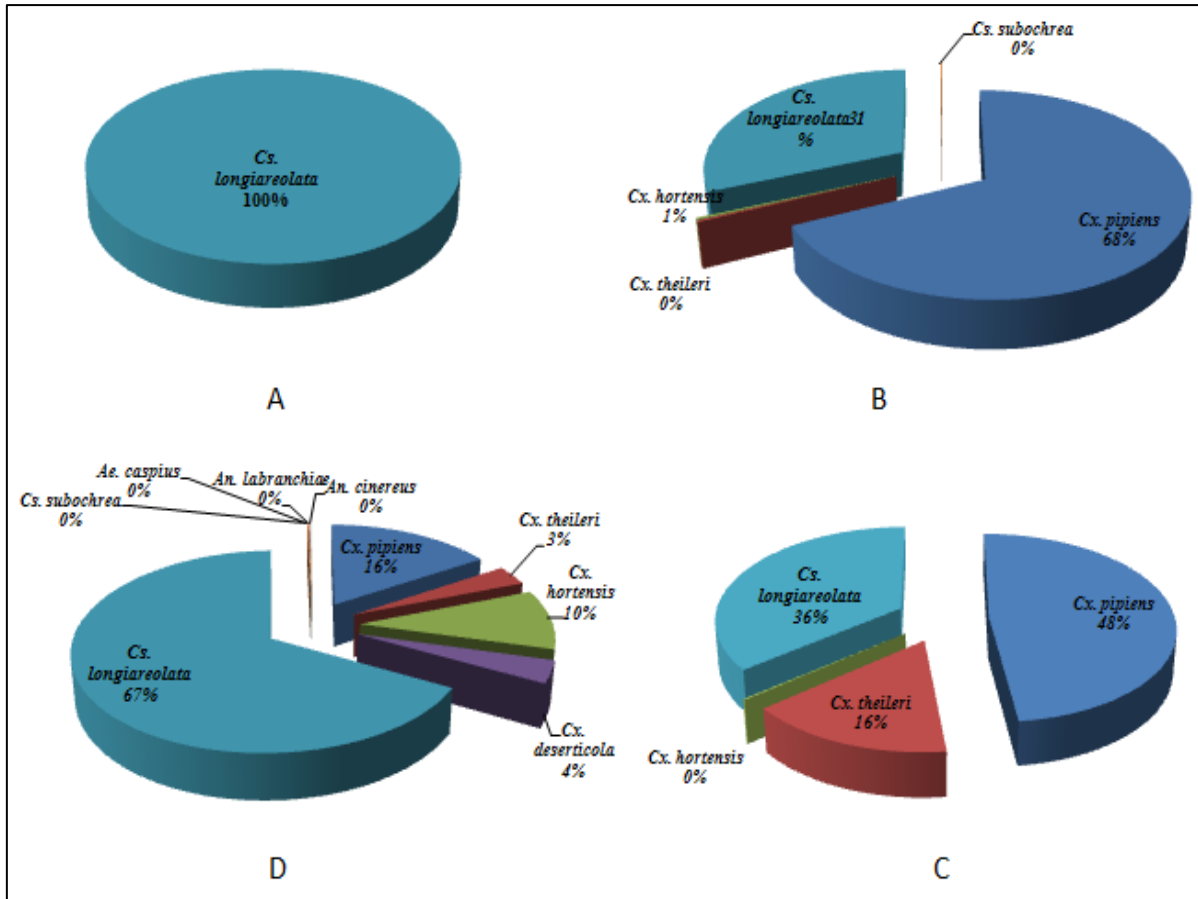


Figure 3: Relative abundance (F%) of culicidae species studied in the four surveyed sites.
 (A: Dhraa Aissi, B: Foum Toub, C: Forage Parc and D: Timgad).

Ecological Index of Structure

According to our results, 8275 individuals were collected from the different stations of the Batna region with a total richness of 9 species. The results presented in Table 4 shows the total richness, the Shanon & Weaver diversity index (H'), the maximum diversity (H'_{max}) and the equitability (E). It was found that the station of Foum Toub occupies the 1st place from the point of view of the number of mosquito larvae collected (N=3470), followed in second place by the station of Timgad with a total of 1823, then Forage Parc with 1521 and Dhraa Aissi 1461 larvae. The diversity index reveals values, ranging from 0 for the station of Dhraa Aissi to 1.532 for the

station of Timgad, this value presents a rich population in species (9 species), the equitability to compare the structures of the populations displays values between 0 and 0.738 in the different stations those indicate that the populations were not balanced.

The values of the diversity index oscillate between a minimum of -0.005 bits, the minimum value recorded at the site of Dhraa Aissi this was certainly due to a dominant number of species (dominance of *Culiseta longiareolata*). The highest values were recorded at the site of Forage Parc is 0.612 bits and in the site of Timgad 0.514 bits. The two sites present a medium diversified population or several species are numerically represented (taxonomic richness).

Table 5: Phenogram of species recorded at the four sites during the study period.

Sites	Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
S1	<i>Cs.longiareolata</i>	*	*	*	*	*	*	*	*	*	*	*	*
S2	<i>Cx. pipiens</i>	*	*	*	*	*	*	*	*	*	*	*	*
	<i>Cx. theileri</i>	*					*						
	<i>Cx. hortensis</i>	*									*		*
	<i>Cs.longiareolata</i>	*	*	*	*	*	*	*	*	*	*	*	*
S3	<i>Cs. subochrea</i>		*		*								
	<i>Cx. pipiens</i>	*	*	*	*	*	*	*	*	*	*	*	*
	<i>Cx. theileri</i>	*				*	*	*	*				
	<i>Cx. hortensis</i>											*	
S4	<i>Cs.longiareolata</i>	*	*	*	*	*	*	*	*	*	*	*	*
	<i>Cx. pipiens</i>			*	*	*	*	*	*	*	*	*	*
	<i>Cx. theileri</i>					*	*	*	*	*			
	<i>Cx. hortensis</i>	*				*	*	*				*	*
	<i>Cx. deserticola</i>	*	*					*				*	*
	<i>Cs.longiareolata</i>	*	*	*	*	*	*	*	*	*	*	*	*
	<i>Cs. subochrea</i>												*
	<i>Ae. caspius</i>										*		
<i>An. labranchiae</i>								*					
<i>An. cinereus</i>								*					

(S1: Dhraa; S2: Forum Toub; S3: Forage parc; S4: Timgad)

Phenology of Species Collected in the Batna Region

The determination of the phenogram of Culicidae species was established according to monthly observations during 2 years of study (Table 5). Most of the species that were found to be abundant in the environments surveyed appeared almost all year round, such as *Culex pipiens* and *Culiseta longiareolata*.

We also noted that *Culex theileri* appeared only in January and June in Fom Toub and from May to September in Timgad. *Culiseta subochrea* only appears in Fom Toub during February and April, while in Timgad it appears in December. The other species (*Aedes caspius*, *Anopheles labranchiae* and *Anopheles cinereus*) were only present for one month in Timgad (Table 5).

DISCUSSION

The analysis of the results of the four sites studied during a period of 24 months in the Batna region, showed that the Culicidian fauna collected belonged to two subfamilies (Culicinae and Anophelinae). It appears from the results found that there was a predominance of the subfamily Culicinae. Our results agree with the same conclusion for the fauna of North Africa and Algeria (Brunhes et al., 1999) and (Boulkenafet, 2006; Merabti, 2010; Tahraoui, 2012; Benhissen, 2016).

For the sub-family Culicinae, we collected four species in three genera: *Culex*, *Culiseta* and *Aedes*, for the genus *Culex*, which was the best represented in this subfamily, we identified four species: *Culex pipiens*, *Culex theileri*, *Culex hortensis* and *Culex deserticola*, the genus *Culiseta* was represented by two species: *Culiseta longiareolata* and *Culiseta subochrea*, and finally, the genus *Aedes* was represented by the species: *Aedes*

caspius. The same species were found by (Benhissen, 2016) in the region of Ouled Djellal.

Representing by our results, 8275 individuals were collected in the different stations of the Batna region, of which *Culiseta longiareolata* and *Culex pipiens* species were the most frequent (4309 and 3385 individuals) respectively, while *Aedes caspius*, *Anopheles labranchiae* and *Anopheles cinereus* species do not exceed 2 individuals.

The low numbers may be due to multiple causes, the most common of which were water quality, reduced egg-laying (as a result of a decrease in the number of female emergences), low quantity of available nutrients (insufficient quantity or quality of food), the drying up of larval sites during the dry seasons, the washing out of sites by rainfall, the slowing down of larval development due to the drop in temperature and mortality by invertebrate or vertebrate predators (Berchi, 2000).

During our surveys, the mosquito most frequently collected in the Batna region was *Culiseta longiareolata* with a rate of 52.07%. This species was widely distributed in the Mediterranean region (Brunhes, 2000). It was found in artificial and natural deposits (Rioux, 1958). During our surveys, it was found in all nests and was collected throughout the year. Lounaci (2003) reported its existence in the marshes of Reghaia, in the cottages of the Agronomic Institute of El Harrach and the stable of El-Alia. Agoun (1996) and Berchi (2000) in Constantine, Hamaidia and Berchi (2018) in Souk- Ahras and (Banafshi et al., 2013) in Iran reported the presence of this species in different types of breeding sites.

The index of specific diversity (Shannon-Weaver index) was high when taxonomic richness was important and the distribution of individuals between taxa was balanced and the index of low values

reflects a less diverse stand with dominant species (Faurie et al., 2003).

Blondel (1979) emphasizes that the greater the diversity index and the greater the number of individuals, the more diverse the stand.

The values of equitability in all the breeding sites vary between 0 and 1 as the minimum recorded at the site of Dhraa Aissi, which reflected a disturbed environment, the maximum observed in the site of Forage Parc, translating a state of strong equilibrium, the index exceeds 0.738. As for the scale of occurrence, the majority of sites (4 sites) recorded constant species belonging to the two genera *Culex* and *Culiseta*, which reflects the heterogeneity and diversity of the environment. This was explained by the ecological characteristics of the study sites.

Clements (2000) found that the mosquitoes were found from the tropics to the Arctic Circle, from low altitudes to mountain tops and on all continents except Antarctica. They can adapt to various climatic conditions or changes in environmental conditions and thus colonize a wide range of ecosystems (Clément, 2000; Becker et al., 2010).

According to Senevet and Andarelli (1947), *Culex pipiens* was the most common species in Algeria and North Africa, the larvae of this species were found in a wide range of habitats such as permanent habitats with poor and rich freshwater vegetation, and temporary habitats with rich freshwater vegetation, they can colonize heavily polluted environments. In the south of France, they were found in septic tanks, cellars, flooded crawl spaces, open sewers and lagoons (Sinegre et al., 1977).

On the other hand, Brunhes (2000) states that *Culiseta longiareolata*, was a widely distributed species in the Mediterranean region. It occurs in both artificial and natural deposits (Rioux, 1958). In contrast, the Anopheles, prefer to colonise more rural sites with water that is

not very rich in organic matter (Salvan and Mouchet, 1994).

CONCLUSION

The systematic study of the larval stages of mosquitoes collected from different sites in the wilaya of Batna allowed us to identify 9 species of Culicidae, belonging to two subfamilies: Culicinae and Anophelinae. The results of the study of the phenogram of the Culicidae species collected in the Batna region indicate that most of the species that were abundant in the environment appear almost all year round, for example, *Culex pipiens* and *Culiseta longiareolata* both species were present all the years, and colonise different types of environment.

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