SYSTEMATIC AND ECOLOGICAL STUDY OF MOSQUITOES (DIPTERA: CULICIDAE) IN THE REGION OF TIMGAD, ALGERIA

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Abstract

We conducted an inventory in the wilaya of Batna more particularly the region of Timgad during the period from January 2018 to December of the same year. Sampling is done monthly using the "Dipping" method to collect the mosquito larvae which were then transported to the laboratory for identification. Five mosquito species were collected in the surveyed site presented by 1035 individuals, these were *Culex pipiens*, *Culex theileri*, *Culex hortensis*, *Culex deserticola* and *Culiseta longiareolata* which appears to be the most abundant with three significant pullulation peaks. This inventory is supplemented by a physicochemical analysis of water to study the correlation between mosquito larval density and site water quality.

Key words: Inventory; Culicidae; Timgad; *Culiseta longiareolata*; Physicochemical analysis.

INTRODUCTION

Biodiversity can be understood as a study of difference, namely what distinguishes and by the same makes original two neighboring entities in space or time (Blondel 1975). The conservation of biodiversity necessarily requires a perfect knowledge of the distribution of fauna and flora (Lobo *et al.* 1997). This fauna, which is represented by all the animal species of an ecosystem, includes insects constituting almost 60% of the animal kingdom (Pavan 1986) and 50% of the diversity of the planet (Wilson 1988).

Mosquitoes, which form very homogeneous groups occupy an important place in the terrestrial fauna as in the aquatic fauna on the one hand and in the transmission of diseases due to their bites on the other hand, make these arthropods a study material important for the biologists (Bouabida *et al*. 2012). The precise identification and knowledge of the functional biodiversity of vectors is an essential step for understanding the risk of re-emergence and the dynamics of vector-borne diseases (Boukraa *et al*. 2013).

The purpose of this study is to draw up a systematic inventory in order to collect information on the vectors and the conditions which favor their multiplication in a given environment. The results of our study will be used for the planning of future mosquito control campaigns in the region of Timgad (Batna, Algeria).

MATERIAL AND METHODS

The study area

The study was conducted in the Daïra of Timgad which is located east of the wilaya of Batna (35° 29′ 45″ N, 6° 28′ 02″ E), 35 km to the east of Batna and 68 km west of Khenchela. The Daïra is made up of two municipalities: Ouled Fadel and Timgad. It occupies an area of 428.48 km^2 and has a hot humid subtropical climate with no dry season (Fig. 1).

The site chosen for the study (35°49'72.35"N; 6°46'58.82"E) was a permanent pond located in a wadi; it is swamped and the waters are clear resulting from the rains and rolling, the site is characterized by a significant presence of vegetation (Fig. 1).

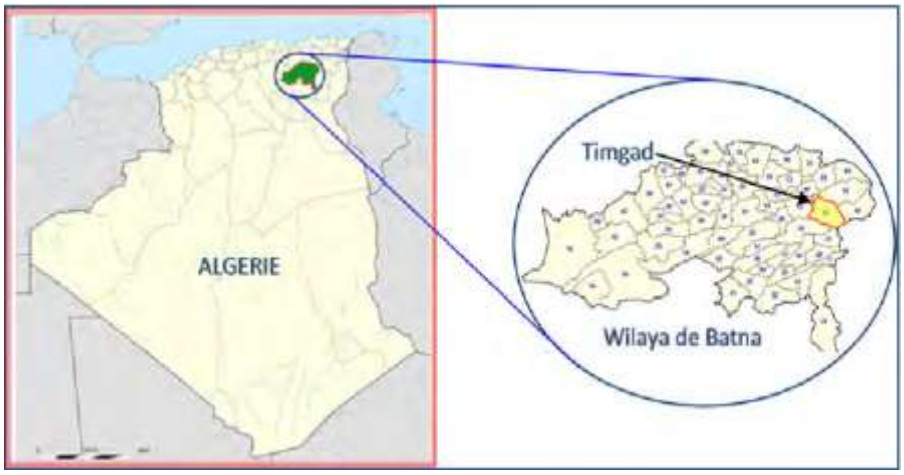

Fig. 1. Geographical location of the Timgad region.

Sampling technics

Sampling was carried out using a ladle with a capacity of 500 ml. It was immersed in to water and then displaced in a uniform manner while avoiding the eddies and a strainer whose netting was 1 mm in diameter. The mosquito larvae thus collected were placed in the containers filled with heeling water, hermetically sealed and labeled (indicating the date of sampling and station) and transported to the laboratory following Bendali-Saoudi (1989).

Culicidae identification key

The generic and specific diagnosis of mosquito requires a careful observation of the entire body of its larva, pupa and adult particularly the morphological characters of their body which are of taxonomic importance, and were taken into consideration for identification.

The systematic identification of the mosquito of the family Culicidae was carried out according to the dichotomous keys suggested by Himmi *et al.* (1995), and computerized according to the identification software of the African mosquitoes (Schaffner *et al.* 2001).

Ecological Index

The ecological indices that hold our attention for the exploitation of our results are the quality of the sampling, the total and average wealth (Blondel 1975), the relative frequency or abundance (Dajoz 1971), the Shannon & Weaver index (Daget 1976), the equidispensing index (Ramade 1984) and the Culicidae faunistic association (Maire and Aubin 1980).

Four physico-chemical parameters (*viz.* pH, conductivity, temperature and density) of the water sampled were measured in the laboratory. The different parameters of the physico-chemical water analysis were measured using the HI 9812-5 multi-parameter device. The impact of the season on the distribution of mosquitoes was also evaluated by a GLM (generalized linear model) on the IBM SPSS statistics version 22 software.

RESULTS AND DISCUSSION

The culicidal fauna of our study site (Timgad) revealed the presence of five species: four belonging to the genus *Culex* (*Cx. pipiens, Cx. theileri, Cx. hortensis* and *Cx. deserticola*), and one species of the genus *Culiseta* (*Cs. longiareolata*). In the region of Timgad, a total number of 1035 individuals of mosquito was collected out of which the species *Culiseta longiareolata* was the most frequent with 709 individuals followed by *Culex pipiens* with 156 individuals and *Culex hortensis* with 145 individuals; the other species *Culex deserticola* (17 individuals) and *Culex theileri* (08 individuals) were poorly represented (Fig. 2).

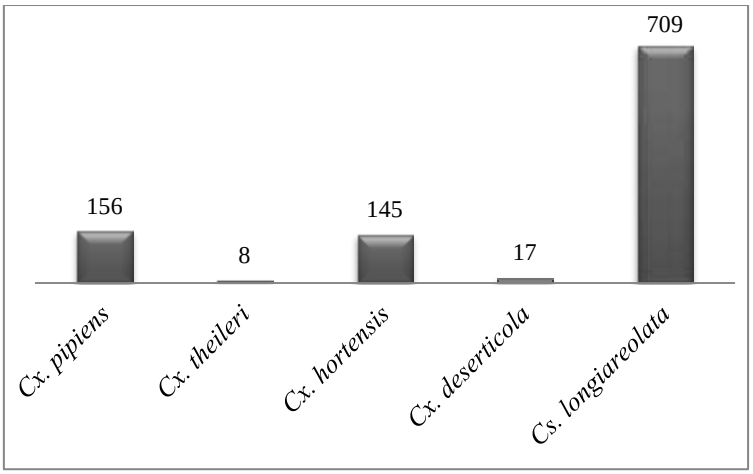

Fig. 2. Number of culicidian species inventoried in the Timgad region during the study period from January 2018 to December 2018.

The analysis of five species culicidal population structure revealed that the month of December presents the greatest abundance with 311 individuals. On the other hand, the month of January shows the smallest population size with only 11 individuals (Fig. 3).

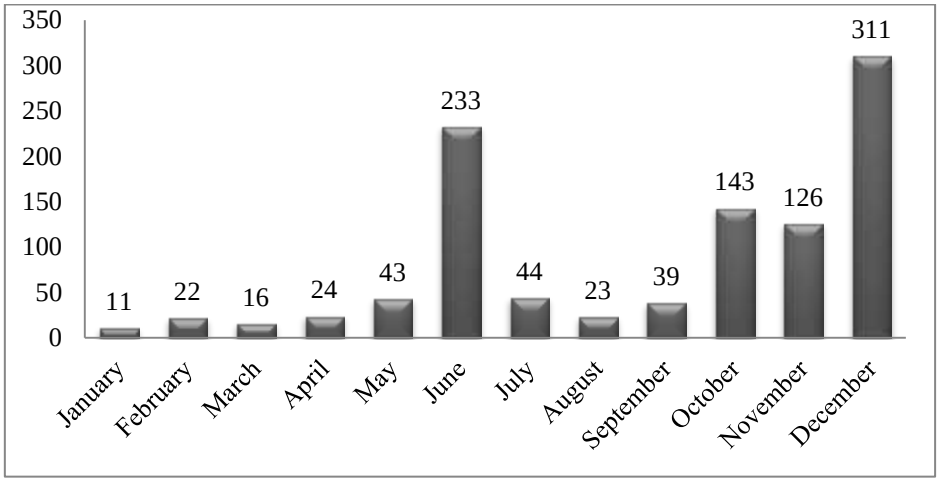

Fig. 3. Monthwise total number of Culicidae species collected in the Timgad region from (January 2018 to December 2018).

In the table 1, *Cs. longiareolata* was dominant by its abundance and frequency (68.50%, 100%, respectively) followed by *Cx. pipiens* (15.07%, 83.33%, respectively). Compared to other species, *Cx. theileri* was rare and poorly represented (0.77%, 16.67%, respectively).

This site is marked by the presence of an ubiquitous species which is *Cs. longiareolata*, a constant species *Cx. pipiens* and two accessory species *Cx. hortensis* and *Cx. deserticola*, while the species *Cx. theileri* was accidentally present in this site.

The Shannon's index (H'), evenness (E), concentration (C) and diversity (D) of Culicidae in the Timgad site are shown in Table 1. The diversity index H' (Shannon-Weaver) and evenness (E) express the complexity of the stand. In the study site, H′ is 1.342 which shows that the population of Culicidae in our region is diversified (H′ > 1). The equitability in this case is 0.575, which indicates that the population of Culicidae is moderately balanced (Extends to 1). The concentration index (C) of the Timgad site is 0.513, this means that there is a 51.3% probability of encountering the same species in the site, which translates into a diversity (D) of the order of 0.486 (Table 1).

Table 1. Ecological indices of the composition and structure of the species of Culicidae collected at the different levels of the Timgad site from January 2018 to December 2018.

Site	**Timgad**		
Species	**F%**	**C%**	**Cate**
Cx. pipiens	15.07	83.33	Cons
Cx. theileri	0.77	16.67	Acci
Cx. hortensis	14.01	33.33	Acce
Cx. deserticola	1.64	25	Acce
cs. longiareolata	68.50	100	Omni
H'		1,342	
Hmax		2,332	
E		0.575	
C		0.513	
D		0.486	

F%: The relative abundance, C%: The frequency of occurrence, Cate: Category, Cons: Constant, Acci: Accidental, Acce: Incidental, Omni: Omnipresent, H': Shanonn-Weaver index, Hmax: Maximum diversity, E: Equity index (regularity index) C: Concentration and D: Diversity.

From the results show in Fig. 4, we are of this opinion that the most dominant species in the study site was *Cs. longiareolata* which presents three pullulation peaks during the months of June and October and the most important pullulation was marked in December. In the same context, two pullulation peaks were recorded during the months of May and October for the *Cx. pipiens* species, and the months of June and November for *Cx. hortensis*.

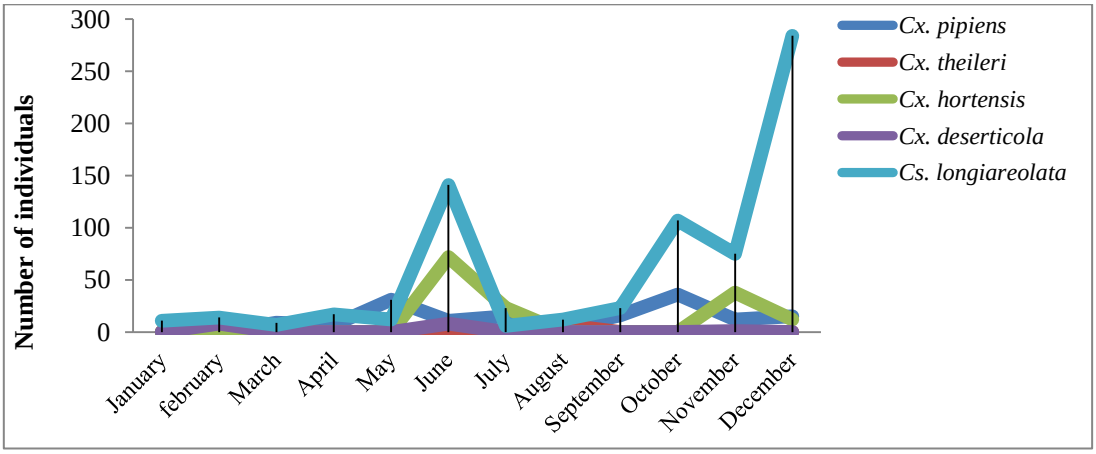

Fig. 4. Monthly headcount individuals of each species collected during the study period from January to December, 2018.

We determined the phenogram of Culicidae species based on monthly observations during a study year (Table 2). The mosquito species, such as *Cx. pipiens* and *Cs. longiareolata* were abundant in the surveyed environment and appeared almost all the year round. The results also show that *Cx. deserticola* and *Cx. hortensis* were found in the Timgad site three to four times, respectively throughout the year. We have also noticed that *Cx. theileri* appeared only twice during the study period in June and August.

Table 2. Phenogram of the species recorded in the surveyed site during the study period from January to December, 2018.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cx. pipiens			*	*	*	*	*	*	*	*	*	*
Cx. theileri						*		*				
Cx. hortensis						*	*				*	*
Cx. deserticola		*				*					*	
Cs. longiareolata	*	*	*	*	*	*	*	*	*	*	*	*

For a better exploitation of the results, we also studied the associations of the Culicidian fauna which make it possible to define the various groups of associated species according to the ecological requirements of their environment (Table 3). From the results of Table 3, it appears that the species harvested in the Timgad region during the study period were present and associated with their congeners.

Table 3. Positive associations of five mosquito species of Culicidae (+ association present) at Timgad.

Species	*Cx. pipiens*	*Cx. theileri*	*Cx. hortensis*	*Cx. deserticola*	*Cs. longiareolat*
Cx. pipiens		+	+	+	+
Cx. theileri	+		+	+	+
Cx. hortensis	+	+		+	+
Cx. deserticola	+	+	+		+
cs. longiareolata	+	+	+	+	

The physico-chemical parameters of the larval site studied are recorded in Table 4. The measurement of water pH in the harvest site shows that this takes the value of 8.77, which indicates that the water in the region was alkaline. The water conductivity in the site was 2.18 μ S/cm. As for the temperature, it was 13.7°C, while the density was equal to 1001.4.

Table 4. Physicochemical parameters recorded in the study site from January to December, 2018.

pH	Conductivity	Temperature	Density	Number of larvae
8.77	2.18	13.7	1001.4	1035

We investigated the effects of different seasons on the composition of Culicidian fauna in the Timgad region. According to the results shown in Table 5, only Roy's largest root test indicates a significant difference (F: 8.645 p: 0.010*).

Table 5. The effect of the seasons on the composition of Culicidian fauna.

	Effect	F	Signification
Seasons effect	Trace of Pillai	1,183	*0.363*
	Wilks Lambda	1,447	*0.267*
	Trace of Hotelling	1,492	*0.290*
	Roy's largest root	8,645	*0.010**

We explain these results by the fact that the region is characterized by the presence of mosquito species whose number of individuals depends on the state of health of the female, food abundance, climatic conditions and egg hatching which is conditioned. According to Aron and Grasse (1966), the mosquitoes of Culicidae are conditioned with temperature and also with the biological or chemical composition of water. The physico-chemical components of water can play an essential role not only in the biology of a species, but also in the structure and dynamics of the entire biocenosis (Berchi 2000).

From our study it appeared that the species *Cs. longiareolata* is the most frequent and abundant in the Timgad site followed by *Cx. Pipiens*; our results agree with Boudjelida *et al*. (2008) which indicate that *Cx. pipiens* and *Cs. longiareolata* represent the most important mosquito species in Algeria. These two species are present almost throughout the year, however, the rest of the three species harvested are found randomly. This scarcity may be due to the quality of the water, the small amount of nutrients available, the drying of the breeding sites corresponding to the dry seasons, leaching from breeding sites by precipitation and slowing larval development due to lower temperatures (Berchi 2000). If the mosquito species belonging to the same group have the same type of biological cycle and are present in the same biotopes, they are not necessarily present at the same time and may never cohabit, there is a chronology (Merabti 2010). Regarding the Shannon-Weaver index we found that the value of H' is 1.342 bits and E take the value of 0.575 our results are close to this calculated value at the level of the Tizi Ouzou region whose H' is 1.85 bits and the equitability of 0.5. Specific diversity index (Shannon-Weaver index) was high when taxon richness was important and the distribution of individuals between taxa was balanced, but the low value index reflects a less diverse stand with dominant species.

We recorded three important peaks for the pullulation of Culicidae during the months of June, October and December; on his part Carron (2007) indicates that the emergences of adults are massive and linked to seasonal meteorological characteristics, the most important are observed after the rains of the vernal and autumnal equinoxes.

The role of the physico-chemical characteristics of water is evident on the distribution of culicidian species. It has been demonstrated that the induction of hatching for certain species was conditioned by the physicochemical quality of the water of the breeding ground (Sinegre 1974) which can play a primordial role, not only in the biology of a species, but also in the structure and dynamics of the entire biocenosis (Berchi 2000). Serghini *et al*. (2010) indicate that the pH of the water also reflects the biological activity of the environment where an alkalinization of the environment can be caused by an increase in photosynthetic activity in the lake. According to Messai *et al*. (2011) the development of Culicidae is conditioned with temperature and also with the biological or chemical composition of water. Similarly, temperature remains essential in terms of increasing the speed of mosquito development (Hadj *et al.* 2013). For his part Sérandour (2007) found that conductivity, pH, salinity, oxygen and bacteria levels appeared to be important parameters which could explain the absence of larvae in certain roosts.

Global warming causes many changes, including temperature, precipitation, humidity and would have a significant impact on mosquitoes and the diseases they transmit. Indeed, this climate change affects the distribution, abundance, behavior and population dynamics of disease vector mosquitoes (Mourot 2020).

Despite the limited area of our entomological survey, we have identified five species of Culicidae belonging to two genera, *Culex* and *Culiseta*, under the sub-family Culicinae. From the point of view of density, the species *Culiseta longiareolata* represents a high proportion of populations in Timgad. This kind of mosquitoes preferentially bite vertebrates especially birds, very rarely humans; the species is considered as a vector of bird Plasmodium. It is noted that the physico chemical characteristics of the water in the surveyed area (Timgad) have impact on the life of the five mosquito species identified.

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