Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2018; 6(1): 838-843

Received: 08-11-2017
Accepted: 09-12-2017

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Inventory and distribution of mosquitoes (Diptera; Culicidae) of the Burgas lakes (Northeast Algeria)

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Abstract
The present investigation examined the biodiversity of Culicidae in the Taoura region at Burgas Lakes during one year from September 2015 to August 2016. Sampling was carried out monthly in the Taoura region at Burgas Lakes, which are located 20 km from Souk-Ahras, (Northeast Algeria). The systematic identification revealed the existence of 18 species: 12 belonging to the genus *Culex* (*Culex deserticola*, *Culex univittatus*, *Culex torrentium*, *Culex peregxiguus*, *Culex impudicus*, *Culex mimeticus*, *Culex martini*, *Culex pipiens*, *Culex theileri*, *Culex brumpti*, *Culex mauritanicus*, *Culex modestus*), three species to the genus *Culiseta*(*Culiseta morsitans*, *Culiseta subochrea*, *Culiseta annulata*), two species of the genus *Anopheles* (*Anopheles coustani*, *Anopheles hyrcanus*), and only one species belonging to the genus *Aedes* (*Aedes pilatus*), respectively. Moreover, ecological indices were calculated in order to determine the dominant species for each Lake.

Keywords: Investigation, biodiversity, Culicidae, systematic

Introduction
In Algeria, as in the world, the Culicidae, constitute the biting insects the most harmful to populations and vectors, formidable parasitic and infectious diseases [1-3]. Regular companions of mosquito control and several methods of fight are carried out against these insects, both for the eradication of these diseases and the reduction of the nuisances, at the level of the urban and tourist centers. The effectiveness of such struggles, whether chemical or biological, is dependent on the knowledge of bio-ecology and the systematic identification of these insects [4, 5]. Culicidae have generally distinct morphological characters, making it easy to identify the family and give a good description.On the other hand, their grouping into sub-families and into genera and subgenera is much more delicate, thus for the determination of species and subspecies [6]. Over the last twenty years, the Culicidian fauna of Algeria has been the subject of a large number of works which are particularly interested in the systematic, biochemistry, morphometry, chemical and biological control [7-9]. To combat these dreaded vectors, man has used chemical control, with mainly synthetic pesticides, which continues to be the major means of control [10]. Biological control is an effective alternative in natural environments because it offers sustainable solutions, thanks to its variety, its specificity, its intrinsic compatibility with the natural environment and its evolutionary power with and without human intervention [11]. According to [12], more than one hundred bacteria have been identified for their potential in biological control. *Bacillus thuringiensis var israelensis* is currently one of the most widely used pest control species [13-18], and *Bacillus sphaericus* [19], on the other hand, the natural regulation of mosquito larvae is largely related to two groups of freshwater fish predators : the first are *Pseudophoxinus callensis*, *Pseudophoxinus guichenoti* [20], and the second is *Gambusia affinis* [21, 22]. On the other hand Hydracarians have shown their efficacies in reducing of Culicidae populations [23]. Another source of biological control is presented by the use of herbal products; it is one of the best alternatives for the fight against Culicidienne. Thus, the study of herbal preparations without adverse effects in non-target organisms and which are readily biodegradable is one of the research goals for vector control [24]. The present study was devoted in the first part, to the systematic determination of species, Culicidae level of two lakes "Lake Burgas Taoura", and establish the list of species in the region of Souk Ahras (Northeast of Algeria). The second part consists in determining the structural characterization of stands by ecological indices.

2. Material and Methods

2.1 Presentation of the study area

The district (Wilaya) of Souk-Ahras is located in northeastern Algeria (36 ° 17'11 "N, 7 ° 57'4" E). It is limited to the north-east by the wilaya of El Tarf, to the northwest by the wilaya of Guelma, to the south by the wilaya of Tébessa, to the southwest by the wilaya of Oum El Bouaghi and to the east by Tunisia (Figure 1). The district (wilaya) of Souk-Ahras covers an area of 4.359.65 km², represents only 0.18% of the entire national territory, it is divided into 26 communes. The site of the present study is rural and covers two lakes each divided into four stations, the two lakes located three kilometers from the Daira of Taoura. The study area was visited from September 2015 to Augest 2016.

Fig 1: Geographical location of the Burgas lakes (Souk-Ahras) study site (Source Directorate of Planning and Land Management of Souk Ahras.)

2.2 Study Stations

The sampling have been realised during a period of 12 months, from September 2015 to August 2016, at two lakes (Burgas), spaced about 50 m. Each lake has four stations on the edge of the lake. The stations were selected according to the accessibility to the water.

2.3 Culicidae

Culicidae are mecopteroid, nematocera, Diptera, Insects remarkable by the progressive evolution which affects at the same time the imago and the larva. The adult presents a size of 5 to 20 mm, a body composed of three distinct parts: head, thorax and abdomen. Culicidae are holometabolic, with aquatic pre-imaginal stages (eggs, larva, nymph) and adult aerial stage, with clear sexual dimorphism. Females are hematophagous, responsible for the transmission of multiple pathogens (Protozoa, arbovirus and microfilaria) [2].

2.4 Sampling technique

The sampling covers two rural sites in the lakes of Burgas, each site is divided into four stations. Culicidae sampling was carried out using a ladle with a capacity of 500 milliliters, the latter is immersed in water and then moved in a uniform movement avoiding "Dipping". Sorting of the specimens was done in the laboratory and then kept for routine use [18].

2.5 Conservation technique

Only larvae having reached the fourth stage of Culicidae are reliably identified. The larvae once dead, are kept in alcohol 60 ° to 70 °. The tubes are labeled with the location and date of sampling. On the other hand the nymphs will be raised until the emergence, to confirm the identification of the species on the imago [8].

2.6 Culicidae identification key

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 are to be examined. The systematics of Culicidae has been carried out mainly using computer software [25] and dichotomous keys, that of [26].

2.7 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 [27], the relative frequency or abundance [28], the Shannon & Weaver index [29], and the equidispensing index [30].

3. Results

The list of Culicidae species recorded in the two rural sites is given in Table 1 and 2. The results showed the existence of 18 species identified at the two study sites. Regarding the number of species the difference is not important. As far as diversity is concerned, the species present at the level of the first site *Culex deserticola*, *Culex univittatus*, *Culex*

torrentium, *Culex peregxiguus*, *Culex impudicus*, *Culex mimeticus*, *Culex morsitans*, *Culiseta subochrea*, *Culiseta annulata* and *Anopheles coustani* are absent at the second site. On the other hand, the *Culex martini* and *Anophesles hyrcanus* species present at the second lake do not appear at the first Lake. That is, each site has a faunistic feature.

Table 1: Total Wealth of Culicidae in the first Burgas Lake (September 2015 to August 2016).

Months / Species	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.
Culex deserticola Kirkpatrick1924	/	/	/	130	/	/	/	/	/	/	/	/
Culex univittatus Théobald 1903	/	70	70	90	/	/	/	/	/	/	/	/
Culex pipiens Linnaeus 1758	/	80	100	80	/	/	/	/	/	/	/	/
Culex mauritanicus Callot 1940	/	/	20	10	/	/	/	/	/	30	/	/
Culex brumpti Galliard 1931	/	/	30	10	/	/	/	/	/	/	/	/
Culex theileri Theobald 1903	120	/	200	/	/	/	/	/	/	150	/	/
Culex perexiguus Theobald 1903	/	/	40	/	/	/	/	/	/	/	/	/
Culex impudicus Ficalbi 1890	/	/	40	/	/	/	/	/	/	/	/	/
Culex mimeticus Noé 1899	/	/	10	/	/	/	/	/	/	/	/	/
Culex torrentium Martini 1929	/	210	/	/	/	/	/	/	/	30	/	/
Culex modestus Ficalbi 1890	/	/	/	/	/	/	/	/	/	20	/	/
Culiseta annulata Schranck 1776	/	/	/	20	/	/	/	/	/	/	/	/
Culiseta subochrea Edwards 1921	/	/	10	10	/	/	/	/	/	/	/	/
Culiseta morsitans Theobald, 1901	/	/	10	/	/	/	/	/	/	/	/	/
Aedes pilatus Coquillett 1904	30	/	20	/	/	/	/	/	/	/	/	/
Anophele coustani Laveran 1900	/	/	/	/	/	/	/	/	/	50	/	/
Total	150	360	550	350	/	/	/	/	/	280	/	/

Table 2: Total Wealth of Culicidae in the second Burgas Lake (September 2015 to August 2016).

Months / Species	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.
Culex pipiens Linnaeus 1758	/	/	20	/	/	/	/	/	/	/	/	/
Culex mauritanicus Callot 1940	/	/	/	30	/	/	/	/	/	/	/	/
Culex brumpti Galliard 1931	/	/	/	10	/	/	/	/	/	/	/	/
Culex theileri Theobald 1903	150	/	10	50	/	/	/	/	/	50	/	/
Culex modestus Ficalbi 1890	/	/	/	30	/	/	/	/	/	/	/	/
Culex martini Medschid1930	/	/	/	30	/	/	/	/	/	/	/	/
Aedes pilatus Coquillett 1904	10	/	/	/	/	/	/	/	/	/	/	/
Anopheles hyrcanus Pallas 1771	/	/	/	/	/	/	/	/	/	20	/	/
Total	160	/	30	150	/	/	/	/	/	70	/	/

The results mentioned in tables 1and 2 showed that the total wealth varies according to the stations. The total richness was important at the first Lake with 16 species; however, it is less important at the second Lake with 8 species (Figure 2 and 3). Regarding the average wealth and the total number of individuals, the first Lake marks higher values with 338 and 1690 against 82 and 410 in the second Lake. The results shown in table 3 show the Shannon Weaver (H ') diversity index values; maximum diversity (H 'max) and Equidispensing index (E). For the first lake the diversity index reveals values varying between zero, (station 3) and a value of 2.5 (Station1), this value presents a stand rich in species (10 species). On the other hand, the second lake has values varying between 0.14 (Station 2) and 0.85 (Station 1), the first value corresponds to a stand characterized by a low number of species, a stand in which there is a dominant species. For equitability, there is a value of 0.06 (Station 4) and a value of 0.90 (station2) of the first lake. There is a balance between populations and all species have the same abundance.For the site, equitability has a value between 0 (Station 4) and 0.85 (Station1). It tends to zero when the different populations are not in equilibrium with each other and when almost all the effective are concentrated on a species, and the second value tends to one when there is a balance between populations and when all species have the same abundance. Relative abundance reveals that *Culex brumpti* is the species the most abundant at the level from the first lake with a number of 430 individuals and 25.44% of abundance, on the other hand species *Culex theileri* is the species the most abundant in the second lake with a number of 310 individuals and 75.60% of abundance. However other species are very rare, because they are present in less than 25% of records (Figure 2 and 3).

Table 3: Total and average wealth. Schanon - Weaver Diversity Index (H '). Maximum diversity index (H 'max). Equidispensing index (E) of Culicidae in the 4 study stations of the two lakes (St: station, St1: St2).

Stations / Species	Lake1				Lake 2			
	St.1	St.2	St.3	St.4	St.1	St.2	St.3	St.4
Culex deserticola Kirkpatrick1924	120	60	/	60	/	/	/	/
Culex univittatus Théobald 1903	50	70	70	70	/	/	/	/
Culex pipiens Linnaeus1758	10	/	40	/	/	/	/	/
Culex mauritanicus Callot1940	/	/	/	40	/	10	/	/
Culex brumpti Galliard 1931	240	120	/	70	/	/	10	/
Culex theileri Theobald1903	/	90	30	20	50	250	10	/
Culex perexiguus Theobald1903	/	/	40	/	/	/	/	/
Culex impudicus Ficalbi1890	70	/	10	/	/	/	/	/

Culex mimeticus Noé 1899	20	/	/	/	/	/	/	/
Culex torrentium Martini1929	240	/	/	/	/	/	/	/
Culex modestus Ficalbi 1890	/	/	/	/	/	/	20	/
Culex martini Medschid 1930	/	/	/	/	/	20	10	/
Culiseta annulata Schranck1776	/	/	10	10	/	/		/
Culiseta subochrea Edwards1921	/	/	10	10	/	/	/	/
Culiseta morsitans Theobald1901	10	/	/	/	/	/	/	/
Aedes pilatus Coquillett 1904	30	20	/	/	/	/	/	10
Anopheles coustani Laveran1900	50	/	/	/	/	/	/	/
Anopheles hyrcanus Pallas1771	/	/	/	/	20	/	/	/
Effectif/Station	840	360	210	280	70	280	50	10
H'/ station	2,5	2,1	0,42	0,43	0,85	0,14	0,73	0,30
S/ station	10	5	7	7	2	3	4	1
H' max	3,32	2, 32	2,80	2,80	1	1,58	2	0
E / station	0,75	0,90	0,15	0,06	0,85	0,08	0,36	0
Total number of individuals	1690				410			
Number of record	5				5			
Total wealth S	16				8			
Richesse moyenne S'	338				82			

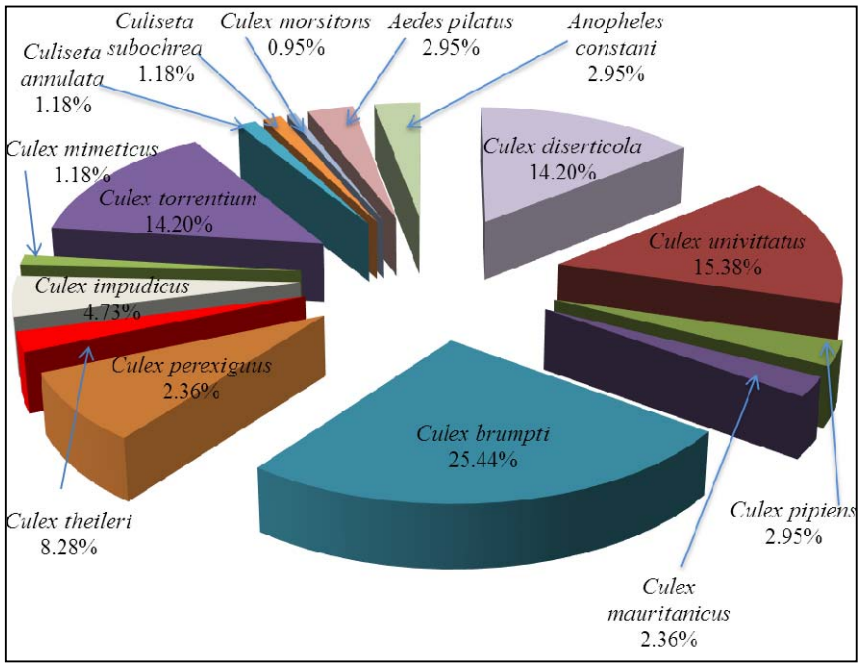

Fig 2: Relative abundance of Culicidae species in the first Burgas Lake (2015-2016).

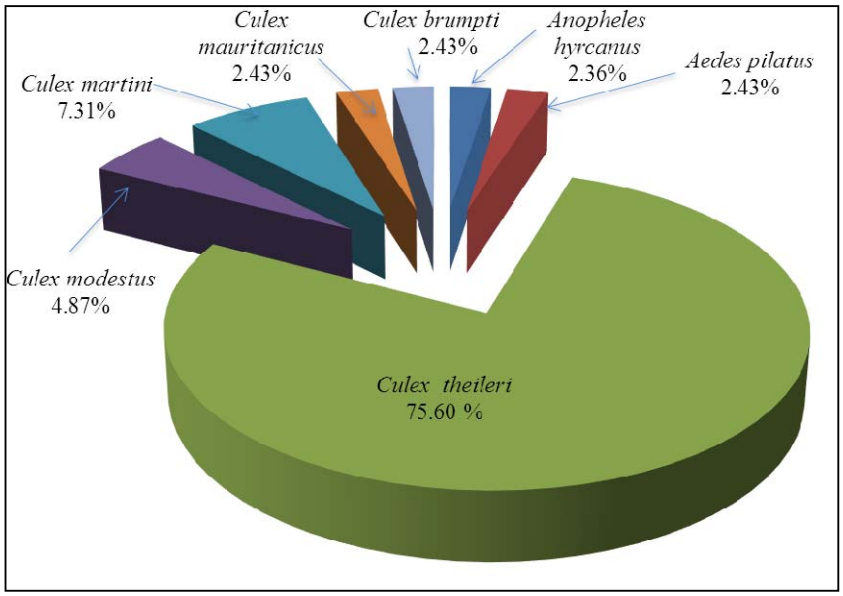

Fig 3: Relative abundance of Culicidae species in the second Burgas Lake (2015-2016).

4. Discussion

In Algeria, the oldest works completed made on Culicidae from Algeria go back in the last century, the searches performed then by [31] constitute with the works of [32, 33] an important step in the knowledge of Algerian Culicidian Fauna. However, the analysis of the results of the two studied sites during a period of 12 months, in the Taoura region, showed that the Culicidian fauna is represented by 18 species, belonging to three sub-families, those of Culicinae represented by the species: *Culex deserticola*, *Culex univittatus*, *Culex mauritanicus*, *Culex brumpti*, *Culex perexeguus*, *Culex modestus*, *Culex pipiens*, *Culex torrentium*, *Culex theileri*, *Culex martini*, *Culex mimeticus*, *Culex impudicus*, *Culiseta annulata*, *Culiseta subochrea* and *Culiseta morsitans*, that of Anophelinae : *Anopheles coustani* and *Anopheles hyrcanus*, and the Aedinae : *Aedes pilatus*.

The species *Culex brumpti* is the best represented and most frequent with a rate of 25.44% in the first Lake. We record that the species *Culex theileri* is abundant in the second Lake with 75.60 %. It is also reported in several regions of Algeria [34]. However other species are very rare because they are present in less than 25% of surveys, what may be due to multiple causes whose the most common are the quality of the water, the drying up of the larval breeding sites corresponding to the dry seasons, slowdown larval development following the temperature decrease and mortality by predators invertebrates or vertebrates [35].

In the semi-arid region of Tebessa, many authors have been largely interested in the morphometric and biochemical characterization of mosquito, [36] noted the presence of 10 species of Culicidae belonging to a single sub-family that of Culicinae, *Aedes caspius*, *Culex pipiens*, *Culex theileri*, *Culex hortensis*, *Culex perexiguus* and *Culex laticinctus*, *Culiseta longiareolata*, *Culiseta annulata* and *Culiseta subochrea*. Whereas in the same region (Tebessa) [37] revealed the presence of 9 species belonging to a single sub-family (Culicinae) and three genera, *Culex* with 5 species (*Culex pipiens*, *Culex theileri*, *Culex hortensis*, *Culex perexiguus* and *Culex laticinctus*), *Culiseta* and *Ochlerotatus*. [38] revealed the presence of 10 species belonging to 3 genera; *Culex pipiens*, *Culex pipiens molestus*, *Culex modestus*, *Culex theileri*, *Culex univittatus*, *Culex perexiguus*, *Culex hortensis* and *Culex laticinctus*, *Culiseta longiareolata* and *Aedes aegypti*, in Tebessa. On the other hand, in the humid region of Skikda, [39]revealed the presence of 13 species in Collo(*Uranotaenia unguiculata*, *Ortopodomiya pulcripalpis*, *Culex pipiens*, *Culex laticinctus*, *Culex impudicus*, *Culex pusillus*, *Culex hortensis*, *Culex theileri*, *Culiseta annulata*, *Culiseta ochroptera*, *Culiseta glaphyroptera*, *Culiseta longiareolata*, *Anopheles maculipennis sacharovi*. On the other hand, in the region of El Taref, [40] noted the presence of 11 species: five belonging to the genus *Culex* (*Culex pipiens*, *Culex hortensis*, *Culex univittatus*, *Culex brumpti* and *Culex modestus*). Three species belonging to the genus Culiseta (*Culiseta subochrea*, Culiseta *annulata* and *Culiseta moristans*), two in the genus Aedes (*Aedes pullatus* and *Aedes vexans*) and one species in the genus Anopheles (*Anopheles coustani*). Similarly, in the same region (El Tarf) at Tonga Lake, [5] identified 13 species representing 6 genera : *Aedes brelandi*, *Aedes vexans*, *Anopheles plumbeus*, *Anopheles labranchiae*, *Culex pipiens*, *Culex perexeguus*, *Culex theileri*, *Culex pusillus*, *Culex modestus*, *Culex impudicus*, *Culiseta longiareolata*, *Culiseta annulata*, *Uranotaenia unguiculata*.

[41]reported the presence of 16 species in the area of Souk-Ahras appartenant to three sub-families, Culicinae represented by 4 genera; *Culex* with 5 species (*Culex pipiens*, *Culex theileri*, *Culex modestus*, *Culex simpsoni*, *Culex quinquefasciatus*, *Culex hortensis* and *Culex arbieeni*); Aedes with 3 species (*Aedes punctur*, *Aedes quasirusticus* and *Aedes pulcritarsis*); Culiseta avec 3 espèces which one could not be identified (*Culiseta longiareolata*, *Culiseta fumipennis*), *Orthopodomyia* represented by a single species (*orpulporalpis*) and the Anopheles genus represented by two species (*Anopheles algeriensis* and *Anopheles labranchiae*). However, the work developed in the Biskra region, interested in the bio-ecology of Culicidae, [42] mentioned 22 species of Culicidae belonging to the six genera: (*Aedes*, *Anopheles*, *Culex*, *Culiseta*, *Uranotaenia* and *Orthopodomya*).

5. Conclusion

The composition of the sampled Culicidian stand in the present study revealed the existence of 18 species: 12 belonging to the genus *Culex*, three species of the genus *Culiseta*, two species of the genus Anopheles, and a single species belonging to the genus Aedes. Relative abundance has revealed that *Culex brumpti* is the most abundant speciesat the level of the first lake, On the other hand the species *Culex theileri* is the most abundant species in the second lake. However *Culex mauritanicus* has been identified for the first time in the present inventory.

6. Acknowledgments

This work was supported by the National Fund for Scientific Research to Pr. N. Soltani (Laboratory of Applied Animal Biology) and the Ministry of High Education and Scientific Research of Algeria to Pr. F. Bendali (CNEPRU and PNR projects).

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