Acta Scientifica Naturalis

Former Annual of Konstantin Preslavsky University of Shumen: Chemistry, Physics, Biology, Geography

Journal homepage: <https://content.sciendo.com/view/journals/asn/asn-overview.xml>

Dipters from the sub-basin of Boumerzoug (Constantine - Algeria)

Bekhouche Naima^{1,2}, Marniche Faiza³, Ouldjaoui Abdallah^{1,2}, Khammar Hichem^{1,4}, Gherraf Nouredine², Mohand Ouali Ferroudja⁵, Mihoubi Lydia⁵

¹*Department of Nature and Life Sciences, Faculty of Exact Sciences and Nature and Life Sciences, Larbi Ben M'hidi University, 04000 Oum EL Bouaghi, Algeria*

²*Laboratoire of Natural Resources and Management of Sensitive Environments (LRNAMS), Larbi Ben M'hidi University, 04000 Oum EL Bouaghi, Algeria*

³*National Veterinary School of El Alia, Algiers, Algeria: préclinique Zoologie*

⁴*Functional Ecology and Environment Laboratory (F.E.E.L), Larbi Ben M'hidi University, Oum El Bouaghi, Algeria*

⁵*Mouloud MAMMERI University of Tizi-Ouzou, Faculty of Biological Sciences and Sciences Agronomic Specialty: Parasitology applied to animal and plant organ*

Abstract: *In order to evaluate the Diptera biodiversity in the Boumerzoug sub-basin, samples were performed at five permanent oueds: El Berda Oued, Boumerzoug Oued, El Guareh Oued, Hmimime Oued, and Sigus Oued. Sampling was carried out monthly during the period from December 2014 to November 2015. The samples were taken using a Surber mesh for the lotic face with size 25 cm * 20 cm * 65 cm, 500 µm net. In total, 53484 individuals comprising 24 families were collected. The Chironomidae family is the most dominant with a population of 43553 individuals (Fc % = 81.43%), followed by the Simuliidae (5137 individuals, Fc % = 9.61%), Psychodidae (1907 individuals, Fc % = 3.57%), Ephydriidae (1509 individuals (Fc % = 2.81%) and Sciaridae (313 individuals, Fc % = 0.59%). However the remained families (Culicidae, Asilliidae, Mycetophilidae, Tipulidae, Syrphidae, Tabanidae, Muscidae, Calliphoridae, Ceratopogonidae, Fanniidae, Cecidomyiidae, Anthomyiidae, Sphaeroceidae, Sciomyzidae, Stratiomyidae, and Phoridae) weree*

poorly represented (between 1 individual ($F_c \% < 0.00\%$) to 281 individuals ($F_c \% = 0.53\%$) were collected with predominance. Finally, compared to the other families, the predominance of the Chironomidae family can be explained by the fact that this family plays an important ecological role in wetlands rich in organic matter, even clearly polluted.

Keywords: Boumerzouk sub-basin (Constantine), Algeria, Diptera, Chironomidae, pollution

Introduction

Oueds are among the most complex and dynamic ecosystems [1]. They play essential roles in the conservation of biodiversity, in the functioning of organisms and in the cycle of organic matter. Hydrographic networks around the world have been more or less modified by human activities [2]. In northern Algeria, the complexity of hydro-systems and the multiplicity of anthropogenic disturbances on the one hand, as well as difficult climatic conditions on the other hand, have led to the growing fragmentation of environments, resulting in deep and rapid changes in invertebrate communities with a loss of diversity and/or demographic imbalances [3]. Diptera is characterized by its great diversity both ecologically and biogeographically. They are answered from the equator to the polar regions and benefit from a great capacity to colonize the most varied biotopes: springs, oueds, lakes, marshes and sea coast. They are among the best represented aquatic invertebrates in terms of the number of species as well as individuals [4]. Many works are carried out in the world concerning the taxonomy and the biology of certain families of Diptera, Brachycera and Nematocera [5-10] and in particular on Culicidae [11-14], on the Diptera Simuliidae [15], on the Ceratopogonidae [16, 17] and on the Psychodidae and Phlebotominae [18]. It should be noted that few works on Nematocera and Brachycera are undertaken in Algeria. At most researchers worked on the bioecology of Culicidae in Constantinois [19], in Tlemcen [20] and in Algiers region and near Tizi Ouzou [21]. The work of Tamaloust [22, 23] was on the bioecology of Nematocera at Algiers (the capital), El Harrach and partially of Biskra. Moubayed et al. [24] worked on the Chironomid Diptera in Algeria. Zerguine et al. [25] worked on the Chironomid Diptera of North East Algeria. Yasri [26] and Berrouane et al. [27] worked on the Reghaia marsh. Haouchine [28] worked in Tiziouzzou. The objectives of this work can be summarized in an inventory of Diptera in the Boumerzoug (Constantine) sub-basin in the northeast of Algeria.

Materials and methods

Study area

The Boumerzoug sub-basin (Constantine) is located in the northeast of Algeria. It occupies a total area of 1832 km². Its geographic coordinates are 35.53° to 36.25° North and 6.28° to 7.4° East longitudes. This sub-basin is bounded to the north by El Khroub, to the south-east by the tell of Ain Kirche, to the East by Ain Abid and the tell of Sigus, to the West by El Guerah and to the South-west by the tell of Ain Mlila. The studied oueds belong to the partial Boumerzoug sub-basin which is located in the northeast of Algeria. It represents a transition zone between the southern slope of the Tellian Atlas and the Highlands [29]. The minimum water temperature recorded in February 2015 is 9.8°C. the highest in July 2015 is 29.7°C and the average is 18.49°C. The average is 500 mm, the minimum of rainfall is 0.15 mm recorded in July 2015, and the maximum of rainfall is 138.15 mm in January 2015. Note that the average humidity recorded is 62.95%. For December 2014, where part of the sampling is done, the average temperature was 7.5°C. The rainfall 72.14 mm, and the recorded humidity is 78.4%.

Stations studied

The Diptera samples were taken from five permanent oueds in the Boumerzoug sub-basin namely: Sigus Oued, El Guareh Oued, El Berda Oued, Boumerzoug Oued, and Hmimime Oued. Sampling was carried out monthly during the period from December 2014 until November 2015. The choice of these stations was done taking into account certain parameters such as altitude, slope, diversity of biotopes, upstream and downstream of agglomerations to estimate the importance of the human impact, and to a certain extent, the regularity of the distribution of the stations along the oueds, as well as conditioning accessibility to stations (Figure 1).

Initially, specific equipment was used at the five stations, such as a pair of boots, gloves and a camera, as well as the equipment to condition the samples are taken, such as labeled jars or airtight bags, all samples are preserved in 70% alcohol for transport and subsequent identification. Before starting the sampling, it is mandatory to complete the field sheet identifying the station, and listing all the characteristics of the oued and its environment. The sample was taken using a surber sampler (mesh size 500 µm). It is used in fast-speed watercourses [31]. They are placed on the substrate that we wish to sample, opening the net facing the current. The hard substrate is rubbed by hand to unhook the organisms which are then entrained by the current in the net (for soft substrates, the Sampling is done on a thickness of a few centimeters).

This is called a quantitative sampling (identical sampled surface whatever the sampling), that is to say, that we can relate the results to a substrate surface. Our biological material is composed of 216 samples collected in the five stations of the Boumerzoug sub-basin (12 months) going from December 2014 until November 2015. The species caught in the Surber net are brought back to the zoology laboratory of the

national higher veterinary school to be determined using dichotomous keys and relevant documents, in taxonomic order [4, 31, 32]. The photos were taken by digital camera Samsung J7pro (Figure 3).

Figure 1. Study site [30] (modified)

- Berda Oued (OB): Loamy and sandy soil; Plants on the banks, some Macrophytes and agricultural land; Water very contaminated with industrial and urban waste (Figure 2a).
- Boumerzoug Oued (OBO): Loamy, sandy and clay soil; little macrophyte and algae vegetation; Water very contaminated with industrial waste (Figure 2b).
- Guareh Oued (OG): Clayey, sandy soil with gravel and rocks; little macrophyte vegetation; little urban waste (Figure 2c).
- Hmimime Oued (OH): Sandy and loamy soil with stones and gravel, shrubs and macrophytes frequent on the edges; municipal wastewater (Figure 2d).
- Sigus Oued (OS): Clay, loamy and sandy soil; Grazing, agricultural and urban pollution; little macrophyte vegetation (Figure 2e).

Figure 2. Sampling sites: a. Berda Oued; b. Boumerzoug Oued; c. Gareh Oued; d. Hmimime Oued; e. Segus Oued (Original)

Table 1. Geographical coordinates of sampling stations

Oueds	Station code	Geographical coordonates	Altitude (m)	Water Deep (cm)
El Berda Oued	BA1	36°10'19.88''N; 6°56'58.22''E	907	15-40
	BA2	36°12'43.27''N; 6°52'38.66''E	767	20-60
	BA3	36°13'12.77''N; 6°48'16.50''E	692	30-50
	BA4	36°14'40.77''N; 6°43'45.28''E	623	20-60
Sigus Oued	S1	36°07'02.89''N; 6°48'55.10''E	803	10-35
	S2	36°08'54.13''N; 6°44'06.20''E	720	20-30
	S3	36°10'23.30''N; 6°42'24.38''E	673	20-40
	S4	36°13'14.96''N; 6°45'34.94''E	622	35-60
El Hmimime Oued	BM1	36°10'32.09''N; 6°34'59.45''E	809	30-60
	BM2	36°14'20.73''N; 6°41'02.36''E	609	30-70

	BM3	36°18'54.66''N; 6°40'07.39''E	561	30-70
	BM4	36°19'50.42''N; 6°37'59.19''E	542	40-70
Boumerzoug Oued	G1	36°06'49.47''N; 6°36'08.68''E	757	20-40
	G2	36°08'16.65''N; 6°36'39.67''E	756	20-40
	G3	36°10'09.52''N; 6°42'16.88''E	678	20-70
El Guareh Oued	H1	36°17'29.61''N; 6°44'04.80''E	665	10-30
	H2	36°17'29.29''N; 6°43'02.77''E	619	20-40
	H3	36°17'34.26''N; 6°41'46.76''E	593	10-40

Figure 3. Inventories of some families of Diptera (adults, larvae, and nymphs) in the Boumerzoug sub-basin
(Original)

- a. Ephydriidae (adult); b. Psychodidae (adult); c. Chironomidae (adult male); d. Simuliidae (adult);
e. Dolichopodidae (adult); f. Cecidomyiidae (adult); g. Empididae (adult); h. Chironomidae (Larvae);
i. Psychodidae (Nymph); j. Anthomyiidae (Larvae); k. Syrphidae (Larvae); l. Psychodidae (Larvae);
m. Dolichopodidae (Larvae), n. Tabanidae (Larvae); o. Culicidae (Nymph); p. Simuliidae. (Nymph);
q. Syrphidae (adult); r. Sciaridae (adult); s. Sphaeroceridae (adult)

Data analysis

To assess the abundance and diversity of families identified in different sampled streams, we used the results of the Surber net. These data were analysed with PAST software (PAleontological STatistics) Version 2.17 [34].

The centesimal frequency (Fc) is the ratio of the number of individuals of a species to the total number of all species combined [35]. It is calculated by the following formula:

$$Fc \% = n_i * 100/N.$$

Shannon's diversity index is calculated from the following formula:

$$H' = - \sum P_i \log_2 P_i$$

H' is diversity index, expressed in bits [36].

P_i is the probability of meeting species i. It is calculated by the following formula: P_i = n_i/N, where n_i is the number of individuals of species i. N is the total number of individuals.

The equitability index (E) corresponds to the ratio of the observed diversity H' to the maximum diversity H'_{max}. It is calculated based on the following formula:

$$E = H'/H'_{max} [37, 36].$$

Results

Water quality

The waters of the studied sites present low salinity near fresh water in the wadis of (berda, el hmimine and boumeezoug with an average between (0.4 and 0.8 g/l) on the other hand the wadis of sigus and guareh presents rather important contents more than 1.2 g/l with average values vary between (0.8 and 1.7 g/l) (Table 2).

For nutrients (nitrogen) the results show a strong pollution by mineral nitrogen compounds, especially ammonia, which represents a good tracer of the municipal urban pollution in the wadis of (ghareh, sigus, el hmimine and boumerzoug with values between 0.4 and 2.6 mg/l especially in ghareh (Table 2).

For the most oxidized mineral forms (nitrate), the five sites present high nitrate contents which exceed the algerian and world average (50 mg/l). These contents fluctuate between 52 and 100 mg/l which are very harmful for the health of the aquatic ecosystems and causes eutrophication problems in the receiving environments (Table 2).

Table 2. Physicochemical water in the five studied oueds

Oued	El Berda Oued				Sigus Oued				El Hmimine Oued			Boumerzoug Oued				El Guareh Oued		
	BA1	BA2	BA3	BA4	S1	S2	S3	S4	H1	H2	H3	BM1	BM2	BM3	BM4	G1	G2	G3
T (°C)	11	12	14	15	14	15	16	16	14	15	15	14	14	16	16	14	13	15
pH	7.8	7.9	8	7.8	8	8	7.9	8.2	7.8	8.1	7.9	7.9	8	8	8.1	8	8.2	8.1
CE (mS/cm)	1407	1611	1696	1551	3581	3001	2927	1811	855	1005	879	1452	1835	1188	1314	2873	2715	1468
Sal (mg.L)	0.7	0.8	0.8	0.8	1.7	1.5	1.4	0.8	0.4	0.5	0.4	0.7	0.8	0.6	0.6	1.5	1.5	0.8
Cl ⁻ (mg.L)	200	173	161	181	446	326	367	266	137	102	134	213	234	211	241	351	319	284
NO ₃ ⁻ (mg.L)	76.6	97.1	63.4	68.1	67.2	115	90	65.3	100	52.	56.9	56.9	87.9	66.8	69.3	69	71.4	82.1

NH ₄ ⁺ (mg.L)	0.2	0.3	0.3	0.3	0.6	0.7	0.5	0.3	0.4	0.4	0.5	0.7	0.3	0.6	0.7	2.5	2.6	0.7
SO ₄ ²⁻ (mg.L)	399	393	383	353	902	425	439	299	130	191	212	360	559	492	339	505	379	366

Global inventories of Diptera from the Boumerzoug sub-basin (Constantine)

The biological material collected consists of larvae, nymphs, exuviae and adults. We obtained 24 families with a number of 53484 individuals. The Chironomidae family is the most dominant with a population of 43553 individuals (Fc% = 81.43%), followed by the Simuliidae family with 5137 individuals (Fc % = 9.61%), then by Psychodidae, Ephydriidae and Sciaridae, with populations of 1907 individuals (Fc % = 3.57%), 1509 individuals (Fc % = 2.81%) and 313 individuals (Fc % = 0.59%) respectively. Concerning the other families such as Culicidae, Asiliidae, Mycetophilidae, Tipulidae, Syrphidae, Tabanidae, Muscidae, Calliphoridae, Ceratopogonidae, Fanniidae, Cecidomyiidae, Anthomyiidae, Sphaeroceidae, Sciomyzidae, Stratiomyidae and Phoridae are poorly represented with numbers varying from 01 individuals (Fc % = 0.002%) to 281 individuals (Fc % = 0.53%). The list of families obtained from the sorting carried out on samples from the five oueds in the Boumarzoug sub-basin is mentioned in Table 3. The dominant presence of the Chironomidae family compared to the others describes that this family plays explained that this family plays an important group important role in wetlands unctingf wich as rich in organic matter, even polluted We note the presence of 08 families of Diptera of medical and veterinary interest in this sub-basin, and we also note the dominant position of the Simuliidae in this station with 5137 individuals, followed by the Psychodidae with 1907 individuals. Also, 1509 individuals are to be noted for the family Sciaridae. Regarding the other families, they intervene with values ranging between 1 and 313 individuals (Table 3). Culicidae and Simuliidae are two families that can spread several diseases such as malaria, filariae as well as many arboviruses and onchocerciasis (oued blindness). They are also the largest group of vectors of pathogens transmissible to humans.

Table 3. Total number of inventoried Diptera families at the Boumerzoug sub-basin
(December 2014 to November 2015)

Station	Boumerzoug sub-basin (Constantine)	
Families	Numbers	Frequency (%)
Ephydriidae	1509	2.821
Psychodidae	1907	3.566
Chironomidae	43553	81.432
Simuliidae	5137	9.605

Ceratopogonidae	2	0.004
Mycetophilidae	22	0.041
Sciaridae	313	0.585
Phoridae	25	0.047
Sphaeroceridae	188	0.352
Cecidomyiidae	10	0.019
Stratiomidae	113	0.211
Empididae	94	0.176
Dolichopodidae	4	0.007
Tipulidae	38	0.071
Culicidae	102	0.191
Calliphoridae	12	0.022
Tabanidae	11	0.021
Fanniidae	17	0.032
Anthomyiidae	1	0.002
Sciomyzidae	27	0.050
Syrphidae	281	0.525
Muscidae	62	0.116
Asiliidae	49	0.092
Sepsidae	7	0.013
Total (N)	53484	100

The abundance of families according to the oueds studied

The abundance of families according to the oueds studied is grouped in Table 4. The families of Diptera are abundant in most stations but their distribution is heterogeneous. The monthly dominance of the 5 oueds in relation to wealth is shown in figures 4 and 5. The total wealth of families varies from month to month for the El Berda Oued, from one to 6 families with a dominance varying from 0.48 to 1 (Figure 5a). The wealth recorded for the Bumerzoug oued varies from one to 9 families with dominance ranging from 0.47 to 1 (Figure 5a). For the El Guareh Oued, we recorded the wealth of 3 to 7 families with a dominance ranging from 0.20 to 0.93 (Figure 5a). On the other hand, El Hmimime Oued has a wealth ranging from 1 to 6

families with the dominance of 0.51 to 1 (Figure 5a). Finally, Sigus Oued represents a diversified wealth compared to other oueds with 4 to 14 families whose dominance varies from 0.57 to 0.92 (Figure 5a). Indeed, according to Moubayed [38], the elements of this group of insects not only have a wide altitudinal distribution but also a great capacity to colonize various polluted or unpolluted biotopes.

Table 4. Total number of families identified for each watercourse using the Surber net in the Boumerzoug sub-basin (Constantine)

Stations	Boumerzoug sub-basin (2014/2015)									
	Oued El Berda		Oued Boumerzoug		Oued El Guareh		Oued El Hmimime		Oued Sigus	
Familles	ni	Fc (%)	ni	Fc (%)	ni	Fc (%)	ni	Fc (%)	ni	Fc (%)
Ephydriidae	185	2.090	153	1.469	723	14.728	176	1.145	272	1.951
Psychodidae	159	1.797	492	4.723	656	13.363	147	0.957	453	3.249
Chironomidae	7069	79.876	8245	79.142	2970	60.501	13163	85.669	12106	86.831
Simuliidae	1399	15.808	1319	12.661	106	2.159	1535	9.990	778	5.580
Ceratopogonidae	-	-	-	-	2	0.041	-	-	-	-
Mycetophilidae	1	0.011	1	0.010	4	0.081	1	0.007	15	0.108
Sciaridae	5	0.056	5	0.048	145	2.954	95	0.618	63	0.452
Phoridae	2	0.023	17	0.163	-	-	-	-	6	0.043
Sphaeroceridae	11	0.124	55	0.528	67	1.365	6	0.039	49	0.351
Cecidomyiidae	-	-	-	-	-	-	2	0.013	8	0.057
Stratiomidae	2	0.023	46	0.442	40	0.815	6	0.039	19	0.136
Empididae	-	-	10	0.096	10	0.204	74	0.482	-	-
Dolichopodidae	-	-	-	-	3	0.061	-	-	1	0.007
Tipulidae	-	-	1	0.010	-	-	-	-	37	0.265
Culicidae	1	0.011	-	-	1	0.020	94	0.612	6	0.043
Calliphoridae	1	0.011	10	0.096	-	-	-	-	1	0.007
Tabanidae	11	0.124	-	-	-	-	-	-	-	-
Fanniidae	4	0.045	-	-	1	0.020	-	-	12	0.086
Anthomyiidae	-	-	1	0.010	-	-	-	-	-	-
Sciomyzidae	-	-	11	0.106	-	-	16	0.104	-	-
Syrphidae	-	-	31	0.298	157	3.198	1	0.007	92	0.660
Muscidae	-	-	21	0.202	23	0.469	1	0.007	17	0.122
Asiliidae	-	-	-	-	1	0.020	48	0.312	-	-

Sepsidae	-	-	-	-	-	-	-	-	7	0.050
Total (N)	8850	100.000	10418	100.00	4909	100.00	15365	100.00	13942	100.00

ni: number of individuals; Fc (%): centesimal frequency in %

Figure 4. Graph of the families identified in the various oueds studied around the Boumerzoug sub-basin (Constantine)

Biocenotic indices show that El Guareh oued presents the greatest specific diversity, followed by Boumerzoug, El Berda, Segus and finally El Hmimime (Table 5). The total wealth varies from one oued to another from 13 to 18 families. Regarding dominance, Segus Oued shows 76% compared to the other oueds studied. This is due to the diversity of the environment as well as the livestock (cattle, sheep, and goats) of the Segus region. The different indicators, namely the specific richness, the diversity index, the fairness and the Margalef index, allowed the descriptive study of the population structure. Regarding Margalef's index, we come to the same conclusions since it varies in the strong positive correlation. In fact, in the different stands, the various profiles of the H' , E and Margalef indexes have the presentation. The highest values are recorded in the station's El Guareh Oued with H' and Margalef index ≥ 1 and $E \leq 0.5$. These stations have a well-diversified population and are well represented. The lowest values are recorded at the other stations (H' varied from 0.6 to 0.7, Margalef index from 1.32 to 1.78 and from 0.15 to 0.33 and to a lesser degree at the stations where there exist 3 to 4 very abundant families (Table 5). Also, the monthly equitability for the five oueds varies monthly from 0 to 0.84 (Figure 5b). In general, H' and E increase: on the one hand, with the number of

families and, on the other hand, with the regularity of their distribution of abundance. In other words, a low index is a consequence of a low number of taxa and/or the dominance of a few families.

Figure 5. Total Dominances, Shannon and equitability indexes of Diptera families monthly variation at the different oueds studied

Table 5. Ecological parameters used for the diversity of families encountered in different streams sampled around the Boumerzoug Basin (Constantine)

Stations	Oued El Berda	Oued Boumerzoug	Oued El Guareh	Oued El Hmimime	Oued Sigus
Taxa_S	13	16	16	15	18
Individuals	8850	10418	4909	15365	13942
Dominance_D	0.6638	0.6449	0.4082	0.7442	0.7586
Shannon_H	0.6554	0.7718	1.3060	0.5810	0.6117
Margalef	1.32	1.621	1.765	1.452	1.781
Equitability_J	0.2555	0.2784	0.4711	0.2145	0.2116

Discussion and conclusion

Diptera are taxa with a wide ecological valence, they are polluted resistant, eurybiont, and withstand high temperatures. Among the different families, Simuliidae abounds in environments rich in organic matter, factors favourable to the proliferation of immature stages [39]. The families encountered in this group are of unequal importance. Our results are similar to those found by Goetghbuer [40] in France who described more than 42 species of Chironomidae. The latter is involved in the stability of ecological balances, such as the larvae of certain species of Chironomidae which constitute more than 10% of the food of fish and amphibians in lakes and swamps [41, 27] in at the National Agronomic School of El Harrach (Algeria), listed 12.5% of Diptera including Culicidae, Cecidomyiidae, Sciaridae, Chironomidae, and Psychodidae. Chaib et al. [42] collected 488 individuals from the Chironomidae family in the Sigus Oued located in Northeastern Algeria. Bousloukia and Yahiaoui [43] confirm that the Chironomidae family is the most dominant with a number of 565 individuals in 3 stations in El Guareh Oued (Ain Mlila). On the other hand, 13 families were noted by Gouga in 2014 on fauna biodiversity in Sebkhet Bazeraui south of Sétif. In fact Lounaci [44] recorded 985 species listed throughout Algeria, among the number of 810 insects, Diptera represents 369 species. Zougaghe et al. [45] recorded at Soummam watershed a dominant number the Chironomidae with 34.1%, the Simuliidae with 9.4% in spring. On the other hand, and in summer the relative abundance of Chironomidae (57.06%) is high and the Simulidae is less represented with 1.94%. Finally, in the hunting reserve of Zeralda [46] identified 11 families of Diptera with a rate of 38.59% of which the Sphaeroceridae are the most abundant with 18.14%, the Psychodidae with 12.71%, the Scatopsidae with 10.67%, the Phoridae with 9.12%, the Cecidomyiidae with 6.5% and finally come the Chironomidae with a low rate of 4.37%.

Our results compared to those reported by many authors, revealed that Algeria water bodies are vulnerable to the effects of environmental changes linked to human activities. There is a need to observe and assess these variations in the scale of global climate changes. It is reported that the presence of Syrphidae larvae of the genus *Eristalis* sp. in our station shows that this family also has a tolerance in pollution as in Chironomidae. Indeed the presence of the species *Eristalis tenax* is also explained by the tolerance of this Diptera to pollution. On the other hand, its small number could be explained by the non-tolerance to the salinity of this site. According to Udday et al. [47] in India, this species tolerates pollution and is considered as bioindicators of pollution. The Culicidiennes species currently known in Algeria are 48 in number [13]. *Culex pipiens* and *Culiseta longiareolata* represent the most important mosquito species in Algeria [48]. All known species from West Africa to the south of Sahara belong to the genus *Simulium* and their number is around 30 [50]. Thus, 20 species of *Simulia* have been harvested in West Algeria [15]. According to Bousloukia and Yahiaoui [43], 132 families of Psychodidae were recovered in 3 stations of El Guareh Oued (Ain Mlila). According to Matile [9], the species of the genus *Psychoda* are pathogenic since they develop in

stables, farms or drains for house wastewater. There are 8 families of Diptera of medical and veterinary interest captured in the Boumerzoug East sub-basin. This value is lower compared to Tamaloust [23] who noted the total number in El Alia stable was 18 families. The climate plays an important role in the appearance of these families. The Culicidae inventory in the Biskra region was carried out by Merabeti and Laid [50] in four different stations, namely Chetma: 15 species; Biskra: 4 species; Sidi Okba: 15 species and Bordj Ben Azouz: 11 species. These different numbers can be explained by the difference in environment between a stable sub-humid bioclimatic stage found in Algiers and a semi-arid bioclimatic stage around the sub-dam of Boumerzoug in Constantine and another in the South of Biskra with Saharan climate. This is also due to the presence of large cottages of different natures and the abundance of vegetation around these stagnant waters. Besides, these places are far from any human intervention. On the other hand, the number in the other stations with low values especially for our study station which contains only natural gites in contrast to urban gites.

The percentages of families of Diptera with medical and veterinary interest collected in the Boumarzoug sub-basin vary between 0.004% and 9.61%. These are the Simuliidae which is present in abundance with a percentage of 9.61% followed by the Psychodidae with a percentage of 3.57% then the Culicidae with 0.19%, then the Muscidae, Calliphoridae, and Tabanidae with percentages of 0.11% and 0.02% respectively. Finally, Ceratopogonidae, and Fanniidae were present with a very low percentage (0.003%). These results confirm those found by Benmoussa et al. [51] in Khoumane Oued in Morocco which reported that the Diptera represents 15.15% of the total fauna harvested. They composed of 5 families with different percentages: Chironomidae (70.64%), Simuliidae (28.82%), Tabanidae (0.38%), Ptychopteridae (0.12%), and Stratiomyidae (0.04%). Also, sand flies are Nematocera vectors of different forms of *leishmaniasis*, prevalent in particular in large North African foci. These are emerging diseases and closely related to the state of the environment [52]. Regarding the Fanniidae known mainly because most of the species are associated with humans and are of medical and forensic importance are little represented in our study region with 0.01%. Dominguez and Pont [53] noted in New Zealand that fanniidae are the inhabitants of wooded areas, and are relatively rare in open landscapes. Males of almost all species form swarms in shaded areas and females can be attracted to decaying organic matter and excrement. In reality, the presence of Psychodidae in our study station is explained by the presence of the release of ammonia from the urine of animals surrounding this basin. The capture of many other species of Diptera in this station can also be explained by the proximity of agricultural land occupied by vegetable and flower crops (Empididae and Chironomidae). From these results, we can see that the Boumerzoug Basin is a polluted area which can be a hotbed of certain diseases. It would be interesting in the future to take certain protective measures to preserve the aquatic environments. It is also essential to build and maintain in good working order the treatment facilities and wastewater treatment plants. Existing regulations must be put in place to prohibit the illegal removal of sand from the oueds. To this end,

emphasis must be placed on educating and raising awareness of the population through information media so that they can become aware of the importance of water and its quality.

References

- [1]. Dynesius, M.; Nilson, C., Fragmentation and flow regulation of oued systems in the northeast third of the world, *Science*, **1994**, 266, 753-762.
- [2]. Everard, M.; Powell, A., Rivers as living systems. *Aq. Cons. Mar//Freshwat. Ecosyst.*, **2002**, 12, 329-337.
- [3]. Lounaci, A., Recherche sur la faunistique, l'écologie et la biogeography des macroinvertébrés des cours d'eau de kabylie (Tizi-Ouzou, Algérie). Thèse de doctorat d'état en biologie. Université Mouloud Mammeri de Tizi-Ouzou (Algérie), **2005**, 208 p.
- [4]. Tachet, H.; Bournaud, M.; Richoux, PH., Introduction à l'étude des macro invertébrés des eaux douces (Systématique élémentaire et aperçu écologique). Association française de limnologie **1980**.
- [5]. Perrier, R., La faune de France, Diptères - Aphaniptères. Ed. Delagrave., Fasc.8. Paris, **1937**.
- [6]. Seguy, E., Les moustiques de l'Afrique Mineure, de l'Egypte et de la Syrie. Encyclopédie-entomologique., Ed. P. Le Chevalier. Paris, **1924**.
- [7]. Seguy, E., La biologie des Diptères. Encyclopédie entomologique. Ed. Paul Lechevalier, Paris. sér. A, XXVI, **1950**.
- [8]. Seguy, E., Ordre des Diptères (Diptera Linné, 1758): 449-744. In: Grasse P. P., Traité de Zoologie, anatomie, système nerveux, biologie. Insectes supérieurs et Hemipteroïdes. Ed. Masson et Cie., Paris. T. X, fasc. I. **1951**.
- [9]. Matile, L., Diptères d'Europe occidentale. Ed., Paris. T.I. Boubée. **1993**.
- [10]. Matile, L., Les Diptères d'Europe occidentale. Biologie Brachycères Schizophores. Atlas d'entomologie. Ed. Boubée. T.II., Paris, **1995**.
- [11]. Seguy, E., Les moustiques d'Europe. Ed. Paul Lechevalier, Paris, **1923**.
- [12]. Rioux, J. A.; Guivard, E.; Pasteur, N., Description d'*Aedes (Ochlerotatus) coluzzin.* sp. (Diptera – Culicidae) espèce jumelle A. du complexe detritus. *Parasitologia*, **1998**, 40, 353-360.
- [13]. Brunhes, J.; Rhaim, A.; Geoffroy, B.; Angel, G.; Hervy, J.P., Les Culicidae de l'Afrique méditerranéenne, logiciel d'identification et d'enseignement, IRD, **1999**.
- [14]. Brunhes, J.; Hassaine, K.; Rhaim, A.; Hervy, J. P., Les Culicidae de l'Afrique méditerranéenne: espèces présentes et répartition (Diptera - Nematocera). *Bull. Soc. Ent. France*, **2000**, 105(2), 195-204.

- [15].Gagneur, J.; Clergue-Gazeau, M., Les Simulies d'Algérie (Diptera, Simuliidae). I. Premières données biogéographiques et écologiques sur les espèces de l'Ouest algérien. *Annales de Limnologie*, **1988**, 24(3), 275-28.
- [16].Delecolle, J.C., Cératopogonidés (Diptera, Nematocera) de Los Monegros. *Bol. S.E.A.*, **1999**, 24, 137.
- [17].Kremer, M.; Delecolle, J. C.; Baily-Choumara, H.; Chaker, E., Cinquième contribution à l'étude faunistique des Culicoides (Diptera, Ceratopogonidae) du Maroc. Description de *C. callotin*. sp. *Cah. O.R.S.T.O.M., Sér. Ent. Méd. Parasitol.*, **1979**, 17(3), 195-199.
- [18].Abonnec, E., Les Phlébotomes de la région Ethiopienne (Diptera, Psychodidae). Ed. Organisme rech. sci. techn. Outremer (O. R. S. T. O. M.), Paris, **1972**.
- [19]. Berchi, S., Bioécologie de *Culex pipiens*. (Diptera, Culicidae) dans la région de Constantine et perspective de lutte. [Thèse] Doc. Es-science. Université de Constantine, Algérie, **2000**.
- [20].Hassaine, K., Biogéographie et biotypologie des Culicidae (Diptera – Nematocera) de l'Afrique méditerranéenne. Bioécologie des espèces les plus vulnérantes (*Aedes caspius*, *Aedes detritus*, *Aedes mariaae* et *Culex pipiens*) de la région occidentale algérienne. Thèse Doc. d'état. Univ. Tlemcen, **2002**.
- [21]. Lounaci, Z., Biosystematique et bioecologie des culicidae (Diptera, Nematocera) en milieux rural et agricole. [Thèse de Magistère], Institut National Agronomique, El-Harrach, Algérie, **2003**.
- [22].Tamaloust, N., Bioécologie des nématocères en milieux suburbain, lacustre et agricole. [Mémoire Ingénieur] Inst. Nati. Agro., El-Harrach, Algérie, **2004**.
- [23].Tamaloust, N., Bioécologie des nématocères dans l'Algérois. Essai de lutte biologique par *Metarhiziumanisopliae* contre les larves de *Culex pipiens* Linné, 1758 (Nematocera, Culicidae). [Thèse Magister], Inst. Nati. Agro., El-Harrach, Algérie, **2007**.
- [24].Moubayed, J.; Lounaci, A.; Lounaci-Daoudi, D., Non-biting midges from Algeria, North Africa (Diptera, Chironomidae). *Ephemera*, **2007**, 8(2), 93–99.
- [25].Zerguine, K.; Samraoui, B.; Rossaro, B., A survey of chironomids from seasonal pounds of Numidie, Northeastern Algeria. *Bioll. Zool. Agr. Bachic.*, **2009**, Ser. II. 41(3), 167–174.
- [26].Yasri, N., Diversité, écologie et biogeography des macro invertébrés de quelques affluents du Mazafran. [Mémoire de Magister], Université Bab Ezzouar, Algérie, **2009**.
- [27].Berrouane, F.Z.; Derdoux, W.; Doumandji, S.; Souttou, K., Résultats des captures des invertébrés en particulier des diptères dans les pièges lumineux dans une bergerie à l'E.N.S.A. d'El Harrach. Journées Nati. Zool. Agri. For., 19-21 April, El-Harrach, Algérie, **2010**.
- [28].Haouchine, S., Recherches sur la faunistique et l'écologie des macroinvertébrés des cours d'eau de Kabylie. [Mem. Magister], En Sciences Biologiques, Option: Ecologie et Biodiversité Animale des

- Ecosystèmes Continentaux, Université Mouloud Mammeri de Tizi ousou, Faculté des Sciences Biologiques et Sciences Agronomiques, Tizi ousou, **2011**.
- [29].Sahli, L.; El Hade. E. O. M.; Afri-Mehennaoui, F.Z., Utilisation d'indices pour l'évaluation de la qualité des sédiments: cas du bassin Boumerzoug (Algerie). *European Scientific Journal*, **2014**, 35, 333-343.
- [30].Agence du Bassin. Hydrographique (ABH), Les Cahiers de l'Agence N° 8. Le Bassin du Késbir - Rhumel. Agence de Bassin Hydro-graphique Constantinois - Seybouse-Mellegue, Ministère des Ressources en Eau., **2002**.
- [31].Malavoi, J. R.; Souchon, Y., Description standardisée des principaux faciès d'écoulement observables en rivière: clé de détermination qualitative et mesures physiques. *Bull. Fr. Pêche Piscic.*, **2002**, 365/366, 357-372.
- [32].Thomas, A., Travaux sur la taxonomie, la biologie et l'écologie d'insectes torrenticoles du sud-ouest de la France (Ephéméroptères et Diptères: Dixidae, Cecidomyiidae, Rhagionidae et Athericidae) avec quelques exemples de perturbations par l'homme. Thèse d'Etat. Université de Toulouse, **1981**.
- [33].Stephen, A.; Marshall.; Ashley, H.; Kirk-Spriggs; Burgert, S.; Muller; Steven, M.; Paiero; Tiffany, Y.; Morgan, D.; Jackson; Kirk-Spriggs, A. H.; Sinclair, B. J. Manual of Afrotropical Diptera, Volume 1. **2017**.
- [34].Hammer, Q.; Harper Dat, D.; Ryan, P., Past: Paleontological Statistics Software Package for Education and Data Analysis. *Palaeontologia Electronica*, **2014**, 1, 1–9.
- [35].Ramade, F., Eléments d'écologie - Ecologie Fondamentale. Edit. Mc Graw-Hill., Paris, **1984**.
- [36].Dajoz, R., Précis d'écologie. Edit. Gauthier-Villars, Paris, **1975**.
- [37].Pielou, E. C., An introduction to mathematical ecology. Wiley Press, New York, **1969**.
- [38].Moubayed, Z., Recherches sur la faunistique, l'écologie et la zoogéographie de trios réseaux hydrographiques du Liban: l'Assi, le Litani et le Beyrouth. [Thèse de Doctorat]es Sciences, Univ. Paul Sabatier., Toulouse, **1986**.
- [39].Sellam, N.; Amador, V.; Zougaghe, F.; Moulai, R., L'utilisation des Coleoptera, Ephemeroptera et Diptera comme bioindicateurs de la qualité des eaux de quelques Oueds en Algérie. *Butlletí de la Institució Catalana d'Història Natural.*, **2016**, 80, 47-56.
- [40].Goetghbuer, F., Faune de France-Diptères Nématocères (Chironomidae). Ed. Faune de France, Paris, **1928**.
- [41].Fontaine, M.; Bellen, G.; Ramade, F.; Ancellini, J.; Lelourd, M.; Michel, P.; Gauthier, M.; Soudane, F.; Bella-Santini, D., La pollution des eaux marins. Ed. Gauthier-Villars., Paris, **1976**.

- [42].Chaib, N.; Fouzari, A.; Bouhala, Z.; Samraoui, B.; Rossaro, B., Chironomid (Diptera, Chironomidae) species assemblages in northeastern Algerian hydrosystems. *Journal of Entomological and Acarological Research*, **2013**, 45, 4-11.
- [43].Bousloukia, H.; Yahiaoui, M., Etude des caractéristiques physico-chimique et des invertébrés terrestres et aquatique du oued El Guerah, Ain Mlila. [Mémoire Master]en Hydro-écologie, Université Larbi Ben M'Hidi, Oum el Bouaghi, **2014**.
- [44].Lounaci, A., Diversite de la faune macro- invertebres benthique d'Algerie. 4ème congrès franco - maghrébin de zoologie & 5èmes journées franco-tunisiennes de zoologie korba – tunisie du 13 au 17 Novembre **2014**.
- [45].Zougaghe, F.; Mouni, L.; Tafer, M., Qualité biologique du réseau hydrographique du bassin versant de la Soummam (Nord de l'Algérie). *Larhyss Journal*, **2014**, 17, 21-33.
- [46].Boubrouta, D.; Iguernlaala, H., Contribution à l'étude des arthropodes à intérêts médical et vétérinaire dans les réserves de chasse de Zéralda (RCZ). [Mémoire Master] en Biologie: Entomologie médicale, Université de Blida, **2015**.
- [47].Udday Bhan Singh, A.S.; Ahluwalia, C.; Sharma, R.; Jindal & Thakur, R.K., Planktonic indicators: A promising tool for monitoring water quality (early-warning signals) Laboratory of Algal Biology and Diversity, Department of Botany, Department of Zoology, Panjab University, Chandigarh 160 014., **2013**, India Eco//Env. & Cons: 23–35.
- [48].Boudjelida, H.; Aissaoui, L.; Bouaziz, A.; Smagghe, G.; Soltani, N., Laboratory evaluation of *Bacillus Thuringiensis* (vectobac WDG) against mosquito larvae, *Culex pipiens* and *Culiseta longiareolata*. *Comm. Biol. Sci. Ghent University*, **2008**, 73(3), 603–609.
- [49].Crosskey, R. W., A re-classification of Simuliidae (Diptera) of Africa and its islands. *Bull. Br. Mus. Nat. Hist. Entomology.*, **1969**, 14, 1-195.
- [50].Merabeti, B.; Laid, O. M., Contribution à l'étude des moustiques (Diptera: Culicidae) dans les oasis de la région de Biskra (nord - est d'Algérie). *Actes du Séminaire International sur la Biodiversité Faunistique en Zones Arides et Semi-arides*, **2011**, 185-189.
- [51].Benmoussa, A.; Chahlaoui, A.; Rour, E.; Chahboune, M., Diversité taxonomique et structure de la macrofaune benthique des eaux superficielles de rivière Khoumane. *Moulayidriiss Zerhoun, Maroc. J. Master. Environ.*, **2014**, 5(1), 183-198.
- [52].Ashford, R.W., The leishmaniasis as emerging and reemerging zoonoses. *Int. J. Parasitol.*, **2000**, 30, 1269-1281.
- [53].Dominguez, M. C.; Pont, A. C., Fanniidae (Insecta: Diptera). *Fauna of New Zealand*, **2014**, 71–91.