Chironomid (Diptera, Chironomidae) species assemblages in northeastern Algerian hydrosystems

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Abstract

The aim of this paper was to analyze the distribution of chironomids (Diptera, Chironomidae), and determine their substrate preferences, from two hydrosystems located in northeastern Algeria: the Kebir-East and the Seybouse wadis. Sixty-five species were recorded in 49 sampling sites distributed along the main courses of the two hydrographic nets and their tributaries. The majority of taxa comprised cosmopolitan species widely distributed along these two hydrosystems. *Cricotopus (Cricotopus) bicinctus* showed the highest abundance and frequency of occurrence (29.52%) and was widespread in almost all the sampling sites. Species richness ranged from 4 to 23, Shannon diversity between 0.15 and 0.90, Evenness from 0.23 to 1. A cluster analysis was carried out to represent the different groups of sites sharing similar species composition. Agglomerative cluster analysis grouped the sampling sites into four clusters according to the community data. An Indval analysis was then carried out to detect indicator species for each group of the sampling sites. *Cricotopus (Isocladius) sylvestris* was indicator of the first group of the sampling sites. *Orthocladius pedestris*, *Rheocricotopus chalybeatus* and *C. bicinctus* were indicators of the second group, and *Polypedilum cultellatum* of the third group. The fourth group was not characterized by any species. Indval analysis allowed also to determine species preferences for substrate size: *Corynoneura scutellata* and *Dicrotendipes nervosus* emphasized a preference to fine gravel, and *Glyptotendipes pallens* to fine sand.

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Key words: Algeria, Chironomidae, spatial distribution, substrate-type, Indval analysis, cluster analysis.

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Introduction

Mediterranean wetlands are under tremendous pressure due to numerous factors like demography, human encroachment and climate change (Hollis, 1992; Hulme *et al*., 2001). Loss of wetland biodiversity can only be mitigated through critical knowledge of threats (Battisti *et al.,* 2008; Gibbs, 2000). Such knowledge is compromised when local biodiversity is not well understood, as is the case of northeastern Algeria which houses a wide spectrum of wetlands, many of international importance (Samraoui & Samraoui, 2008). Despite their ecological and biogeographical interests, the aquatic communities of northeastern Algeria have attracted few systematic studies (Samraoui & Menai, 1999; Samraoui & Corbet, 2000; Annani *et al.,* 2012; Samraoui *et al.,* 2012).

The Chironomidae (Diptera) constitute a highly diversified group of aquatic insects frequently occurring in high density in different kinds of ecosystems (Coffman & Ferrington, 1984). The Chironomidae are of great significance in the structure and function of lotic systems due to their great abundance, diversity and occurrence (Cranston, 1995). The larvae of this family are fundamental components in freshwater food webs, occupying different habitats within river basins, with their distribution determined by several factors; among them, substrate size has an important role in the spatial distribution of macroinvertebrate assemblages (Sanseverino & Nessimian, 2001; Brooks *et al.,* 2005).

The understanding of the relationship between species and environment is essential; therefore, every assessment will be more accurate if habitat preferences and indicator species are known (Legendre & Legendre, 1998; McGeoch & Chown, 1998; Tickner *et al.,* 2000). Despite their importance, little is known of habitat preferences of chironomids, especially in the southern Mediterranean, including Algeria (Lounaci *et al.,* 2000a; Lounaci *et al.,* 2000b; Arab *et al.,* 2004; Belaidi *et al.,* 2004; Chaib *et al.,* 2011a; Chaib *et al.,* 2011b).

Sampling in several wadis (water courses with very irregular hydrologic regime) in Kabily du Djurdjura, northern Algeria (Moubayed *et al.*, 2007) generated a list of 87 chironomid species from this area: 8 belonged to Tanypodinae, 3 to Diamestinae, 57 to Orthocladinae and 19 to Chironomiae; 10 species were not described. A total of 53 species were new records for Algeria, 25 of which being also new records for North Africa.

A survey of Chironomids from the Kebir-East wadi and its tributaries in northeastern Algeria (Chaib *et al.,* 2011b) generated a list of 37 widespread chironomid species in the Palearctic. They include 5 Tanypodinae, 15 Orthocladiinae, 4 Tanytarsini and 13 Chironomini.

A similar study was carried out in the Seybouse basin, where 45 chironomid species were collected.

This study aims to analyze the composition of Chironomidae assemblages in the northeastern Algerian hydrosystems along the Kebir-East and the Seybouse wadis. The spatial distribution of the assemblages was examined and chironomids were correlated with substrate size in order to investigate substrate preferences.

Materials and methods

Study area

Forty-nine sampling sites were chosen along the main course of the Kebir-East (23) and the Seybouse wadis (26) and their tributaries on the base of land-use and anthropogenic impacts (Chaib & Samraoui, 2011; Chaib *et al.,* 2011a, 2011b; Khelifa *et al.,* 2011) (Figure 1, Table 1).

According to the subdivision of hydrographic nets in the eastern region of Algeria by the *Agence des Bassins Hydrographiques* (ABH-CSM), our two river systems, the subject of this paper, belong to two different basins: i) the Kebir-East belongs to the watershed of the *Côtiers Constantinois Est* in the extreme north-east of Algeria, and covers a catchment area of 1600 km^2; and ii) the Seybouse basin is the largest sub-basin in the northeastern region, covering an area of 6570 km^2.

These two fluvial systems are an important source of water in the northeastern Algeria, since they supply water for irrigation of large agricultural areas extending from the regions of Guelma to El Kala.

Both the Seybouse and Kebir-East basins represent a mosaic of geomorphodynamic natural conditions, as well as diverse levels of man-made disturbances of a variety of origins (physical: Bouhalloufa and Mexa dams for the Kebir-East and Bouhamdane dam for the Seybouse; chemical: presence of non-point pollutions, and municipal and industrial wastewater).

The climate is typically Mediterranean with a hot and dry summer from June to September, and a cold and rainy winter from October to May.

The substratum of the Kebir-East wadi is composed either of ancient sediments (marls and sandstone) of the Algerian local marine Miocene (equivalent to the continental Aquitanien), degraded slightly on the surface in the east, or more recent Plio-Quaternary sediments corresponding to alluviums of the high and middle terraces of the Kebir-East wadi valley. The recent Quaternary sediments in the valley of Kebir-East wadi comprise silt, sand and stones (Marre, 1987).

The watershed of the Seybouse wadi drains water very slowly over a gentle relief from its source in the highlands of Sellawa and Heracta. In the uplands, it flows through a very fractured and complex structured topography, where the hydrographic net is rarely adapted to the structure (Ghachi, 1986). The effluents are torrential and the longitudinal contours are irregular and stretched. The Seybouse River flows through some depressions containing an alluvial water table (C.G.G., 1971; Djabri *et al.,* 2003). This allows regulation of winter precipitations received by the mountain range. When the river reaches the plain of Annaba, it loses its energy and leaves behind a great load of sediments. The geomorphological characteristics of the plain, gentle slope, sand dune barrier, and inundation-prone areas allow the river to flow easily into the Mediterranean Sea.

All chironomid samples were collected with a Surber net (300 m mesh size, 50 cm width). Sampling was carried out during spring (March-May) and summer (July-September) from 2008 to 2011. Ten hauls were made in the opposite sense of the current along the sam-

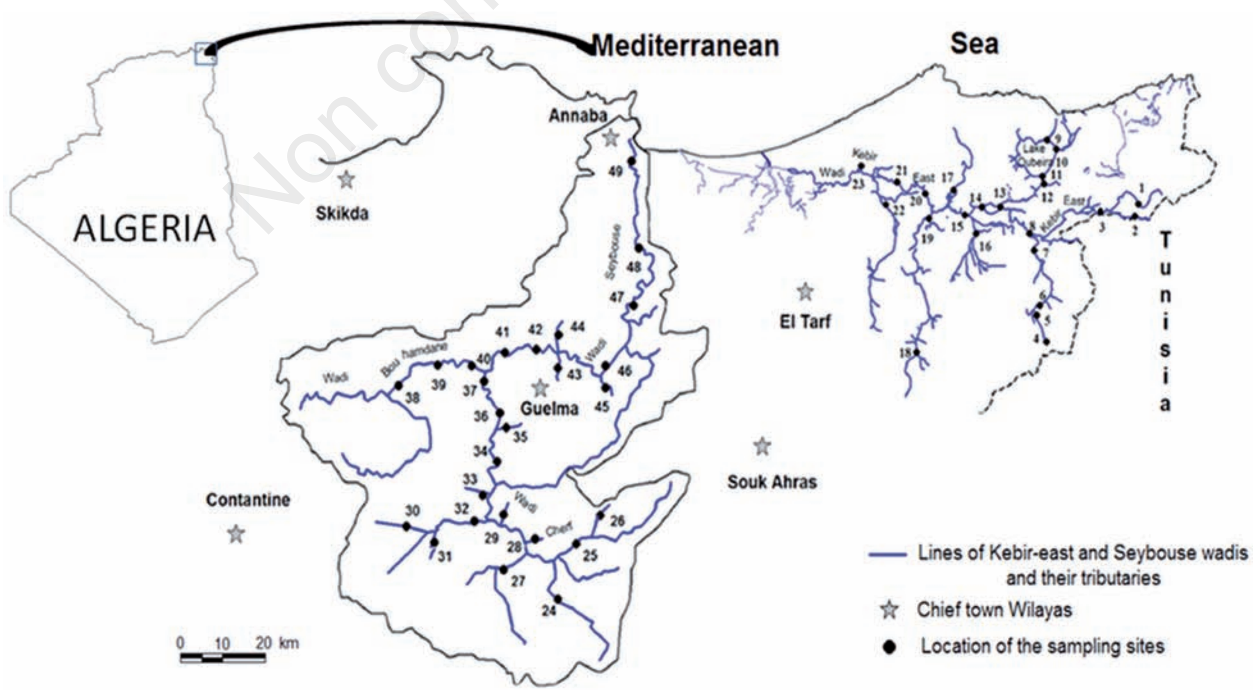

Figure 1. Location of the 49 sampling sites along the Kebir-East and the Seybouse wadis and their tributaries (northeastern Algeria).

Table 1. List of the sampled sites located along the Kebir-East and Seybouse wadis and their tributaries.

No.	Watercourse	Names of the sampled sites	Code	Latitude (N)	Longitude (E)	Altitude (m)	Substrate size	Substrate size classes
1		O. Leben	LEB	8°30'32"	36°46'56"	77	Very coarse gravel	5
2		O. Mellili	MEL	8°30'28"	36°46'50"	80	Very fine gravel	4
3		O. Kebir at R'Mel Souk	RSK	8°30'10"	36°46'55"	80	Very fine gravel	4
4		O. Louar Amont	LAM	8°22'58"	36°36'52"	652	Stones	6
5		O. Louar Aval	LAV	8°21'56"	36°39'01"	200	Silt	1
6		O. Bougous Amont	BAM	8°21'53"	36°39'06"	203	Very fine gravel	4
7		O. Bougous Aval	BAV	8°24'27"	36°42'36"	69	Very coarse gravel	5
8		O. Kebir at Ain Assel	KAS	8°21'57"	36°45'59"	30	Very fine gravel	4
9		Oubéïra 3	OB3	8°23'10"	36°51'47"	24	Silt	1
10		Oubéïra 2	OB2	8°25'15"	36°51'29"	24	Silt	1
11		Oubéïra 1	OB1	8°24'12"	36°49'29"	22	Silt	1
12		O. Messida Aval	MAM	8°24'09"	36°49'23"	22	Very fine sand	2
13		O. Messida Amont	MAV	8°22'30"	36°47'37"	25	Very fine sand	2
	Kebir-east wadi							
14		O. Kebir Ain Khiar	KAK	8°18'51"	36°46'49"	23	Very coarse sand	3
15		O. Guergour	GRG	8°16'52"	36°46'32"	25	Very coarse sand	3
16		O. Kebir Guergour	KGR	8°16'43"	36°46'36"	25	Silt	1
17		O. Bourdim	BRD	8°14'50"	36°47'22"	20	Very fine gravel	4
18		O. Zitoun	ZIT	8°13'02"	36°39'06"	193	Stones	6
19		O. Dardan	DRD	8°13'16"	36°46'39"	15	Silt	1
20		O. Kebir at Anenes	KAN	8°12'48"	36°47'48"	14	Very fine sand	2
21		O. Kebir at Righia	KRG	8°09'35"	36°48'51"	11	Silt	1
22		O. Boulathan	BLT	8°06'06"	36°49'42"	8	Very fine sand	2
23		O. Kebir at Sebaa	KSB	8°09'07"	36°48'59"	10	Silt	1
24		Barrage Sedrata	BSD	36°03.516'	7°27.209'	744	Silt	1
25		Cherf à Sedrata	CPS	36°04.479'	7°29.640'	747	Silt	1
26		Oued Krab	OKR	36°07.210'	7°32.780'	778	Silt	1
27		Cherf à Ksar Sbahi	CKS	36°03.207'	7°19.557'	751	Silt	1
	Seybouse wadi							
28		Oued El Nil	ONL	36°08.380'	7°26.731'	775	Very coarse gravel	5
29		Oued Dbabcha	ODB	36°12.945'	7°19.047'	609	Very coarse gravel	5
30		Oued el Maleh	OML	36°08.893'	7°8.642'	742	Very fine sand	2
31		Oued Beni Mheni	OBM	36°09.207'	7°19.557'	668	Very fine sand	2
32		Barrage Ain Makhlouf	BMK	36°13.528'	7°17.783	643	Stones	6
33		Oued El Aare	OAR	36°13.572'	7°19.186'	609	Stones	6
34		Cherf à Ain Makhlouf	CMK	36°14.462'	7°18.626'	600	Stones	6
35		Oued Cheniour- Affluent	OCH	36°14.877'	7°20.610'	742	Stones	6
36		Cherf à Ain Hsainia	CHS	36°25.415'	7°18.788'	270	Very fine gravel	4
37		Cherf à Medjez Amar	CMA	36°26.526'	7°18.677'	273	Very fine gravel	4
38		Bouhamdane à Hammam Debagh	BHD	36°28.012'	7°15.673'	305	Very fine gravel	4
39		Bouhamdane à Mermoura	BMR	36°26.522'	7°16.292'	480	Stones	6
40		Bouhamdane à Medjez Amar	BMA	36°36.592'	7°18.615'	274	Very fine gravel	4
41		Seybouse à Salah SalahSalah	SSS	36°27.697'	7°20.382'	251	Stones	6
42		Seybouse à El –Fedjouj	SFJ	36°28.893'	7°24.926'	222	Stones	6
43		Oued Zimba – effluent	OZM	36°26.020'	7°18.452'	291	Very fine sand	2
44		Oued Bradâa	OBR	36°30.803'	7°27.037'	285	Very coarse sand	3
45		Oued Helia – effluent	OHL	36°25.415'	7°18.788'	144	Stones	6
46		Seybouse à Zemzouma	SZM	36°24.795'	7°36.676'	143	Very fine sand	2
47		Seybouse à Boudaroua	SBD	36°31.667'	7°42.307'	100	Very fine gravel	4
48		Seybouse à Chihani	SCH	36°41.002'	7°45.527'	12	Very coarse sand	3
49		Seybouse à Dreân	SDR	36°39.216'	7°46.968'	18	Very fine gravel	4

Table 2. List of species recorded in 49 sites from two northeastern Algerian watercourses (Kebir-East and Seybouse wadis) between 2007 and 2011. Subfamilies are presented in phylogenetic order and genera in alphabetic order.

Taxa	Frequency of occurrence (%)	Total abundance of species
Tanypodinae		
Conchapelopia pallidula (Meigen, 1818)*	1.17	103
Procladius choreus (Meigen, 1804)°	0.75	66
Rheopelopia ornata (Meigen, 1838)#	1.12	99
Tanypus punctipennis Meigen, 1818°	1.36	120
Zavrelimyia punctatissima (Goetghebuer, 1934)*	0.19	17
Diamesinae		
Sympotthastia spinifera (Serra-Tosio, 1968)#	0.01	1
Prodiamesinae		
Prodiamesa olivacea (Meigen, 1818)°	0.05	4
Orthocladiinae		
Cardiocladius fuscus Kieffer, 1924#	0.82	72
Corynoneura scutellata Winnertz, 1846°	0.14	12
Cricotopus (Cricotopus) bicinctus (Meigen, 1818)°	29.52	2606
Cricotopus (Isocladius) sylvestris (Fabricius, 1974)°	9.39	829
Eukiefferiella bedmari Vilchez-Quero & Laville, 1987*	0.25	22
Eukiefferiella claripennis (Lundbeck, 1890)°	0.8	71
Eukiefferiella gracei (Edwards, 1929)*	0.01	1
Eukiefferiella ilkleyensis (Edwards, 1929)*	0.09	8
Eukiefferiella sp.1 (Thienemann A., 1926)*	0.02	2
Hydrobaenus distylus (Potthast, 1914)#	0.93	82
Hydrobaenus sp.1 Fries, 1830*	0.02	2
Limnophyes minimus (Meigen, 1818)*	0.01	1
Metriocnemus sp.1 Van Der Wulp, 1874*	0.03	3
Orthocladius (Euorthocladius) ashei Soponis, A., 1990*	0.25	22
Orthocladius (Euorthocladius) rivicola Kieffer, 1911#	3.15	278
Orthocladius (Orthocladius) excavatus Brundin L., 1947*	1.36	120
Orthocladius (Orthocladius) rubicundus (Meigen, 1818)*	0.61	54
Orthocladius pedestris Kieffer, 1909#	3.18	281
Paracladius conversus (Walker, 1856)#	0.01	1
Parakiefferiella gracillima (Kieffer, 1924)#	0.05	4
Parametriocnemus stylatus (Kieffer, 1924)°	0.27	24
Paraphaenocladius sp.1 Thienemann, 1924*	0.01	1
Paratrichocladius rufiventris (Meigen, 1830)*	2.38	210
Paratrissocladius excerptus Walker, 1846#	0.12	11
Psectrocladius (Psectrocladius) psilopterus (Kieffer, 1906)*	0.11	10
Psectrocladius sordidellus (Zetterstedt, 1838)#	0.02	2
Rheocricotopus chalybeatus (Edwards, 1929)#	3.32	293
Rheocricotopus fuscipes (Kieffer, 1909)*	1.6	141
Thienemanniella vittata (Edwards, 1924)°	0.33	29
Tanytarsini		
Cladotanytarsus mancus (Walker, 1856)#	1.08	95
Cladotanytarsus sp.1 Kieffer, 1921*	0.35	31
Micropsectra atrofasciata (Kieffer, 1911)#	0.06	5
Paratanytarsus sp.1 (Thienemann A. & Bause, 1913)*	1.22	108
Rheotanytarsus photophilus (Goetghebuer, 1921)#	0.71	63
Rheotanytarsus sp.1 Thienemann A. & Bause, 1913*	0.51	45
Tanytarsus sp.1 Van der Wulp, 1874°	1.11	98
Chironominae		
Chironomus plumosus (Linnæus, 1758)°	2.41	213
Chironomus riparius Meigen, 1804#	7.15	631
Chironomus sp.1 Meigen, 1803*	2.7	238
Cryptochironomus defectus (Kieffer, 1913)*	0.32	28
Cryptochironomus rostratus Kieffer, 1921#	0.11	10
Cryptotendipes sp.1 Beck & Beck, 1969*	0.01	1
Dicrotendipes nervosus (Stäger, 1839)°	0.82	72
Einfeldia sp.1 Kieffer, 1924*	0.01	1
Genus near Tribelos*	0.23	20
Glyptotendipes pallens (Meigen, 1804)#	0.08	7
Harnischia fuscimana (Kieffer, 1921)°	0.1	9
Microchironomus tener (Kieffer, 1818)#	0.01	1
Microtendipes pedellus (De Geer, 1776)°	0.74	65
Paracladopelma camptolabis (Kieffer, 1913)#	0.01	1
Phaenopsectra flavipes (Meigen, 1818)*	0.02	2
Polypedilum (Tripodura) scalaenum (Schrank, 1803)°	3.09	273
Polypedilum cultellatum (Goetghebuer, 1931)°	8.7	768
Polypedilum laetum (Meigen, 1818)*	0.03	3
Polypedilum nubifer (Skuse, 1889)*	4.73	418
Robackia sp.1 Sæther O.A., 1977*	0.02	2
Synendotendipes dispar (Meigen, 1830)#	0.19	17
Synendotendipes impar (Walker, 1856)*	0.01	1

*Species recorded in the Seybouse wadi. °Species recorded in both the Kebir-East and the Seybouse wadis. #Species recorded in the Kebir-East. Total abundance was calculated as the abundance from all samples (n=49) pooled together.

pling station, in the middle of the current and near the banks. Samples were preserved in 5% formaldehyde (larvae, pupae), and then examined under a dissecting microscope. The specimens were grouped by morphotypes according to external characteristics visible through the stereomicroscope in the laboratory. Subsequently permanent mounts were prepared in Faure or in Balsam mounting medium, to enable the taxonomic determination of the different morphotypes.

Dataset

A list of species derived from different studies carried out in northeastern Algeria between 2007 and 2011 (Chaib *et al.,* 2011b) were collected in a database.

The list was based on larval collections, with species identification aided by collection of prepupae and of mature pupae. Italian Keys for larvae determination were used (Ferrarese, 1983; Ferrarese & Rossaro, 1981; Nocentini, 1985; Rossaro, 1982) along with keys for Palaearctic pupae (Langton & Visser, 2003).

Substrate size was ranged into six classes (ISO 14688-1) according to the particle size: i) class 1: silt, <0.063 mm; ii) class 2: fine sand, 0.063-0.200 mm; iii) class 3: medium-coarse sand, 0.200-2 mm; iv) class 4: fine-medium gravel, 2-20 mm; v) class 5: coarse gravel, 20-63 mm; vi) class 6: cobble, 63-200 mm.

Data analysis

Quantitative samples collected in the 49 sampling sites were considered in the statistical analyses; the mean abundance of each taxon per site was considered. Rare species were included in the analysis (Smith *et al.,* 2001) resulting in a total of 65 taxa.

Relative abundances of species were transformed by log (10) to normalize counts. To avoid a problem of logarithm zeroes, the value 1 was added to each abundance. Groups of samples sharing the same type of community composition were defined using a hierarchical cluster analysis (Goodall, 1973) with Ward's linkage method and Euclidian distance measure.

Multi-response permutation procedures (MRPP) (Biondini *et al.,* 1985) were used to test the reliability of the groups obtained.

The species characterizing each cluster were identified with indicator species analysis (IndVal; Dufrêne & Legendre, 1997). A second Indval analysis was carried out considering the sampling sites grouped based on substrate size. This method combines information on the concentration of species abundances in a particular group and the faithfulness of occurrence of a species in a particular group. Indicator values were tested for statistical significance using a randomization (Monte Carlo) technique (McCune & Grace, 2002). The significance was tested by carrying out 10,000 Indval analyses.

Agglomerative cluster analysis, MRPP and Indval analysis were performed with the R environment 2.15.1 (R Development Core Team, 2009).

Species richness, diversity and evenness indices were also calculated (Shannon & Weaver, 1949).

Results

Sixty-five Chironomidae taxa belonging to four subfamilies were identified (Table 2). Orthocladiinae showed the highest generic richness (29 taxa). This subfamily showed a proportional abundance of 59%, Chironominae 31%. Tanytarsini and Tanypodinae were the less frequent and abundant with approximately 6% and 5%, respectively.

C. bicinctus showed the highest abundance (2606 ind*m^{-2}) and frequency of occurrence (29.52%) and was widespread in almost all the sampling sites (Table 2), followed by *C. sylvestris* and *Polypedilum cultellatum* with total abundance of 829 and 768, and a frequency of occurrence of 9.39% and 8.7%, respectively. Total abundance and the fre-

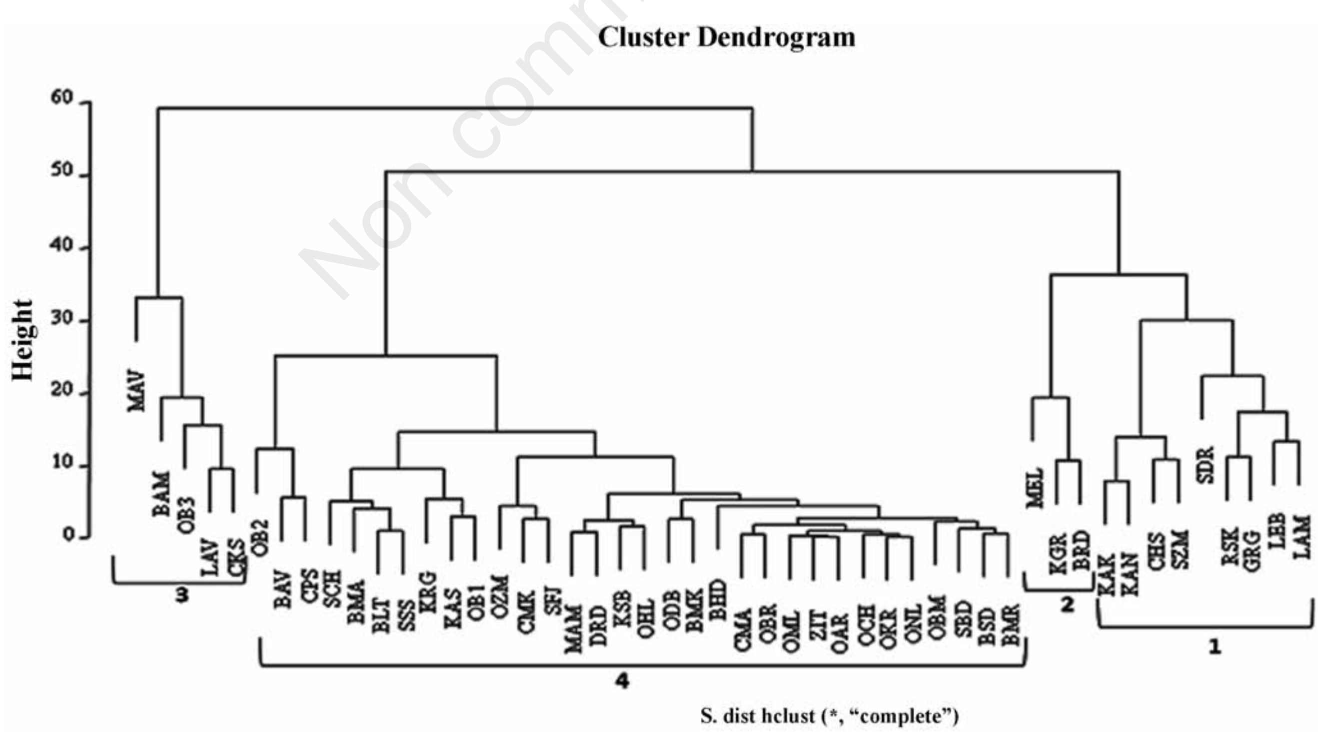

Figure 2. Agglomerative cluster dendrogram based on chironomid communities sampled in the Kebir-East and the Seybouse wadis (2008-2011) (see Table 1 for site codes and names of sampling sites for each group).

Table 3. Chironomids diversity, richness and evenness for the each sampling sites (see Table 1 for site codes; see Figure 2 for clusters).

No.	Sampled sites	Cluster	Diversity	Species richness	Evenness
1	LEB	1	0.75	14	0.66
2	MEL	2	0.64	14	0.58
3	RSK	1	0.81	11	0.75
4	LAM	1	0.75	15	0.66
5	LAV	3	0.81	12	0.76
6	BAM	3	0.63	11	0.57
7	BAV	4	0.80	14	0.73
8	KAS	4	0.79	22	0.72
9	OB3	3	0.75	8	0.76
10	OB2	4	0.64	9	0.64
11	OB1	4	0.72	9	0.71
12	MAM	4	0.84	16	0.76
13	MAV	3	0.74	15	0.64
14	KAK	1	0.64	11	0.54
15	GRG	1	0.62	11	0.59
16	KGR	2	0.62	12	0.54
17	BRD	2	0.80	14	0.72
18	ZIT	4	0.15	5	0.23
19	DRD	4	0.82	13	0.76
20	KAN	1	0.75	9	0.73
21	KRG	4	0.71	12	0.59
22	BLT	4	0.73	11	0.66
23	KSB	4	0.76	12	0.70
24	BSD	4	0.25	9	0.28
25	CPS	4	0.83	19	0.72
26	OKR	4	0.77	9	0.77
27	CKS	3	0.90	18	0.86
28	ONL	4	0.78	8	0.85
29	ODB	4	0.89	15	0.87
30	OML	4	0.83	9	0.89
31	OBM	4	0.63	9	0.61
32	BMK	4	0.72	7	0.77
33	OAR	4	0.75	4	1.00
34	CMK	4	0.89	20	0.83
35	OCH	4	0.77	23	0.68
36	CHS	1	0.81	17	0.74
37	CMA	4	0.89	20	0.85
38	BHD	4	0.73	10	0.75
39	BMR	4	0.80	11	0.81
40	BMA	4	0.70	17	0.64
41	SSS	4	0.85	17	0.78
42	SFJ	4	0.89	17	0.86
43	OZM	4	0.84	23	0.72
44	OBR	4	0.77	12	0.76
45	OHL	4	0.78	19	0,74
46	SZM	1	0.85	17	0.78
47	SBD	4	0.76	15	0.74
48	SCH	4	0.81	16	0.78
49	SDR	1	0.81	15	0.73

Table 4. Chironomid indicator species by group of sites and substrate size (Indval analysis).

Taxa	Taxa assemblages		Substrate size	
	Max class	P	Max class	P
Tanypodinae				
Conchapelopia pallidula	4	0.378	6	0.324
Procladius choreus	3	0.102	1	0.235
Rheopelopia ornata	3	0.144	5	0.575
Tanypus punctipennis	1	0.749	4	0.519
Zavrelimyia punctatissima	4	0.292	3	0.581
Diamesinae				
Sympotthastia spinifera	2	0.057	4	0.746
Prodiamesinae				
Prodiamesa olivacea	4	0.719	4	0.356
Orthocladiinae				
Cardiocladius fuscus	*2*	*0.042*	3	0.417
Corynoneura scutellata	2	0.643	*4*	*0.032*
Cricotopus (Cricotopus) bicinctus	*2*	*0.011*	4	0.510
Cricotopus (Isocladius) sylvestris	*1*	*0.029*	5	0.809
Eukiefferiella bedmari	4	0.691	6	0.571
Eukiefferiella claripennis	2	0.112	6	0.923
Eukiefferiella gracei	4	1.000	4	0.776
Eukiefferiella ilkleyensis	4	1.000	6	0.270
Eukiefferiella sp.1	4	1.000	6	0.898
Hydrobaenus distylus	2	0.116	4	0.807
Hydrobaenus sp.1	4	1.000	3	0.455
Limnophyes minimus	3	0.164	1	1.000
Metriocnemus sp.1	3	0.390	1	0.757
Orthocladius (Euorthocladius) ashei	3	0.537	6	0.745
Orthocladius (Euorthocladius) rivicola	3	0.934	6	0.796
Orthocladius (Orthocladius) excavatus	4	0.609	2	0.342
Orthocladius (Orthocladius) rubicundus	3	0.750	6	0.502
Orthocladius pedestris	*2*	*0.007*	4	0.129
Paracladius conversus	4	1.000	2	0.314
Parakiefferiella gracillima	2	0.114	4	0.271
Parametriocnemus stylatus	2	0.572	4	0.297
Paraphaenocladius sp.1*	4	1.000	6	0.538
Paratrichocladius rufiventris	4	0.265	3	0.542
Paratrissocladius excerptus	3	0.941	6	0.057
Psectrocladius (Psectrocladius) psilopterus	4	0.724	2	0.497
Psectrocladius sordidellus	1	0.569	2	0.725
Rheocricotopus chalybeatus	*2*	*0.009*	3	0.971
Rheocricotopus fuscipes	4	0.387	6	0.118
Thienemanniella vittata	2	0.533	1	0.139
Tanytarsini				
Cladotanytarsus mancus	1	0.586	4	0.466
Cladotanytarsus sp.1	4	0.609	3	0.732
Micropsectra atrofasciata	4	1.000	4	0.754
Paratanytarsus sp.1	1	0.945	4	0.684
Rheotanytarsus photophilus	2	0.319	5	0.539
Rheotanytarsus sp.1	4	0.189	6	0.248
Tanytarsus sp.1	4	0.811	3	0.764
Chironominae				
Chironomus plumosus	2	0.276	1	0.536
Chironomus riparius	4	0.744	2	0.156
Chironomus sp.1	4	0.661	6	0.534
Cryptochironomus defectus	1	0.805	6	0.428
Cryptochironomus rostratus	3	0.065	4	0.632
Cryptotendipes sp.1	1	0.335	2	0.309
Dicrotendipes nervosus	2	0.761	*4*	*0.033*
Einfeldia sp.1	1	0.349	5	0.150
Genus near Tribelos	4	1.000	1	1.000
Glyptotendipes pallens	3	0.379	*2*	*0.036*
Harnischia fuscimana	2	0.638	6	0.276
Microchironomus tener	3	0.140	4	0.756
Microtendipes pedellus	3	0.655	5	0.441
Paracladopelma camptolabis	1	0.357	6	0.530
Phaenopsectra flavipes	3	0.306	4	1.000
Polypedilum (Tripodura) scalaenum	3	0.091	1	0.774
Polypedilum cultellatum	*3*	*0.038*	1	0.616
Polypedilum laetum	1	0.776	4	0.500
Polypedilum nubifer	4	1.000	6	0.211
Robackia sp.1	4	0.155	1	0.937
Synendotendipes dispar	*2*	*0.052*	5	0.124
Synendotendipes impar	4	1	4	0.747

Significant values ($P<0.05$) are in italics (see Figure 2 for groups of sites: cluster analysis). *Species recorded in the Seybouse wadi.

quency of occurrence were calculated from all samples (n=49) pooled together.

Species Richness ranged from 4 (site 33) to 23 (sites 35 and 43), diversity between 0.15 (site 18) and 0.90 (site 27). Evenness values ranged from 0.23 (site 18) to 1 (site 33) (Table 3).

Indicator species were determined for each group of sites and then according to substrate-type. Indicator values are in Table 4, along with statistical significance values calculated by randomization (Monte Carlo) (McCune & Grace, 2002).

The agglomerative cluster analysis (Figure 2) grouped the sampling sites into clusters according to the chironomid species. A 4-group level of the dendrogram was chosen, the MRPP results showing that the groups obtained were statistically different (A=0.302, P<0.005).

Corynoneura scutellata and *Dicrotendipes nervosus* showed the lowest P values (0.032 and 0.033, respectively) and seemed to have a preference to very fine gravel, *Glyptotendipes pallens* presented a P value of 0.036 suggesting a preference for very fine sand substrate (Table 1).

It should be emphasized that the number of larvae recorded of *C. scutellata* and *G. pallens* was very low; only a few larvae were captured in some stations. *D. nervosus* was more abundant in stations KAS (20 larvae) and SDR (12 larvae).

Discussion and conclusions

The percentage distribution of taxa within chironomid subfamilies was in accordance with previous studies (Moubayed *et al.,* 2007; Chaib *et al.,* 2011b), with Orthocladiinae as the most frequent, taxon-richest and abundant subfamily.

C. bicinctus was the most abundant and widely distributed taxon, confirming that the species can tolerate a wide range of substrate size (with a preference for the sandy substrate). In contrast *C. scutellata* was the least abundant, present only in very fine gravel substrates.

The cobble and gravel substrates held the highest number of chironomids among all substrates (Table 1). It was similarly observed (Campbell & Meadows, 1972) that cobble substrates offer the most suitable microenvironments because they supply materials used by the larvae to construct runways and to build cases about their bodies, crevices for protection, sources of attachment, they are also a source of food since rock surfaces are covered with periphyton (mosses and algae).

In contrast, silty stations housed the least number of chironomids (Table 1) due to the fact that they had the least favorable physical conditions, such as high current and low values of organic matter and transparency. However, *P. cultellatum* was found to be dominant there.

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