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Taxonomic Diversity and Benthic Community structure of Watersheds of Medjerda and Joumine (North East of Tunisia)

Slimani Noura, BEJAOUI Mustapha and Boumaiza Moncef
Laboratory of Environment Biomonitoring (Group of Hydrobiology), Faculty of Sciences of Bizerta University of Carthage, 7021, Jarzouna. TUNISIA

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Abstract

This paper presents the analysis of the relationships between benthic communities from two watersheds of north-east Tunisia (Medjerda and Joumine) and habitat characteristics of the sampling sites. Biological material was collected from 6 sampling sites. The results show the presence of at least 80 taxa. Mercuria confusa Frauenfeld, 1863 has the highest relative abundance and frequency, followed by Ostracoda Latreille, 1802 and Echinogammarus pungens H. Milne Edwards, 1840. A statistical method based on classical description parameters (richness, diversity…) showed that the communities are relatively diversified in stations 1 and 4, whereas they are very poor in the other stations. The MDS and PCA analysis allowed identifying spatial features through the succession of benthic stands and its ecological preferences.

Keywords: Medjerda River, Joumine River, macrozoobenthos, taxonomic diversity, community structure.

Introduction

In Tunisia, the identification of the status of benthic fauna of limnic ecosystems has experienced great effort during the last decade[1-6]. The main goal was to fill in important gaps in our knowledge of the distribution of most benthic species while relying on biological zonation (or biotypology) of these populations in their natural context or habitat.

Wetlands constitute the most productive ecosystems of the world with specific ecological characteristics, functions and values[7]. Community structure of benthic organisms is largely determined by the energy equilibrium and nutrient input[8]. There is a strong physical, chemical and biological relationship between benthic communities and the prevailing environment[9].

In our study, we have chosen a river sector in the Eastern part of Tunisia that is hardly known or about which there are no accurate data both concerning the knowledge/identification of the sites and the biology and ecology of the species that inhabit them. Investigating the relationship between the aquatic characteristics of the habitat and the benthic community structure is possible by the use of univaried and multivaried analysis which constitutes the most common method that will reflect particular aspects of the benthic fauna.

Material and Methods

Study area: For our study, we selected 6 stations from two hydrographic basins (figure-1) whose brief characterization is presented as follows: i. The three stations (ST1, ST2 and ST3) of hydrographic basin of Medjerda are also located at a low altitude. ii. (≤ 28m), relatively large in size (from 4,25m to 40m), with highly mineralized water (conductivity= 6360µs/cm, Salinity=3, 6 PSU), a current velocity that is rapid enough (30 cm/s) and with a vegetation/plant cover that is quite dense and rich (table-1). According to Colombani J.[10], this mineralization is related to water salts inflows from tributaries. iii. The three stations (ST4, ST5 and ST6) from the hydrographic basin of Joumine are located at a high altitude, small size. The input of fresh water is mainly influenced by the lithological nature of the substrate with calcareous dominance [11].

Biological dataset: The biological material was collected during six sampling months extending from April to September 2007. Samplings were made by Surber nets [12], with a 20 cm^2 mesh-size, and these were similar to all sites: one sample of 8 to 20 meters in length was taken from each site, covering the entire habitat (water surface and body, aquatic vegetation if present, bottom); twenty-five minutes constituted one sample for each of the sites.

The collected material was stored in Eppendorf tubes and other containers in 70 % or pure ethanol and transported to the laboratory for the identification of taxa which was made at a binocular stereo by the diagnosis of morphological characteristics or traits. The majority of benthic macroinvertebrates are determined to rank species, with the exception of some taxa such as Oligochaeta and Ostracoda whose identification stops at a supraspecific level that can happen to genre.

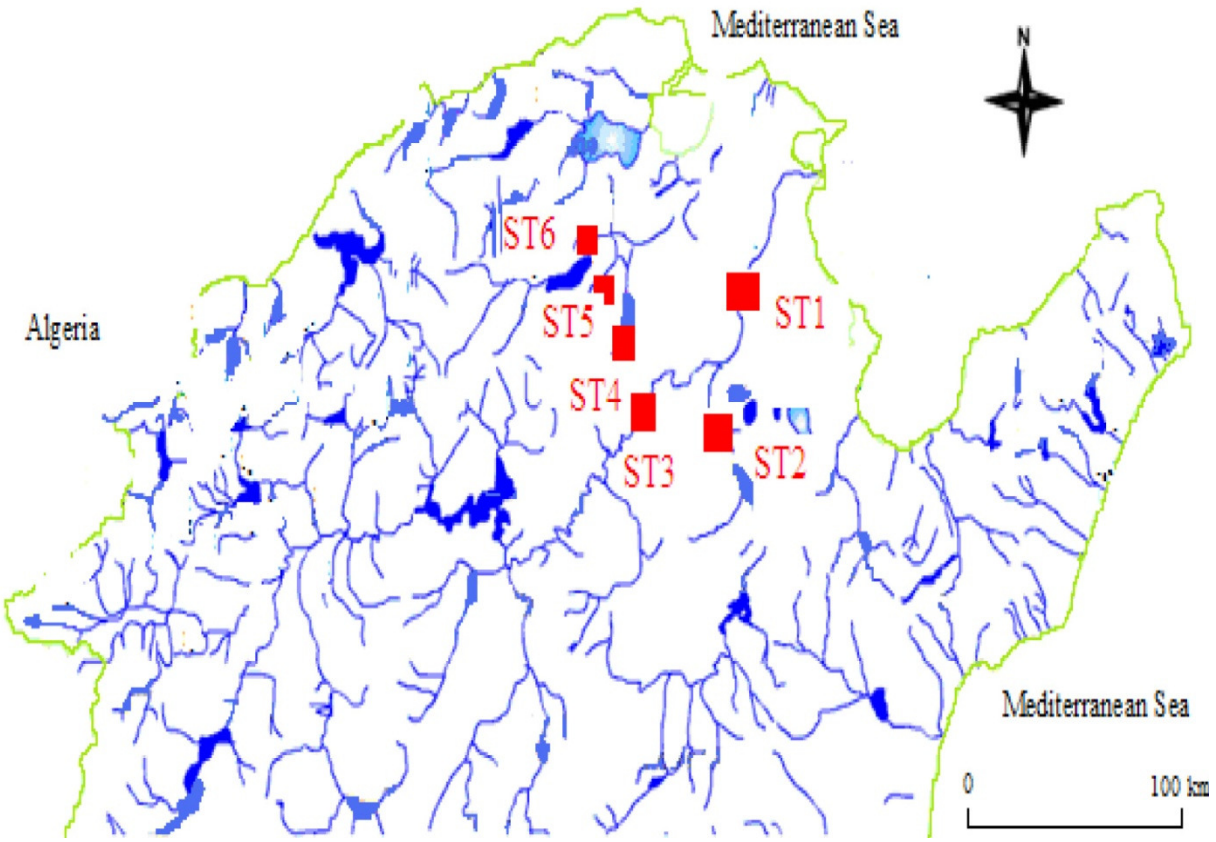

Figure-1
Study area showing the sampling sites

Data analysis: Data analysis implied calculation into two databases: i. "a structure database" including, the mean density, the relative abundance (Pi) of the 88 taxa for each station/date and ii. a "biodiversity indexes" namely taxonomic richness (number of taxa), Shannon diversity (H')[13] and Pielou evenness or (J')[14]and a comparative study between the two watersheds.

The indices were selected to represent different aspects of the biodiversity concept: taxonomic richness for general aspects, diversity within a sample[15], indices of Shannon diversity for heterogeneity of habitats[15], Pielou concept of evenness for evenness compared to a theoretical distribution [17]. In this way, we can appreciate the differences between the two geographical areas from all points of view, and we can carry out a proper comparison.

PCA analyses were performed using PRIMER-6 software[18] after data transformation: Y = Log (X + 1). Similarity coefficient of Bray-Curtis[19] was used to construct the matrix of similarity between the different stations.

Results and Discussion

84774 aquatic and semiaquatic individuals (adults and larvae) belonging to 81 taxa inhabit the six chosen sampling stations. Species' distribution is presented in table-2. Analyzing the communities from a faunistic point of view, we can easily observe that the molluscs are quantitatively dominating, well representing 90% from total macroinvertebrate samples, and this fact is due to the population of three species representing more than 10 % from the total relative abundance which are respectively *Mercuria confusa* (97%), *Pseudamnicola dupotetiana* (33%) and *Phsyella acuta* (13%). However, insects constitute the best dominating share or proportion in qualitative terms with almost 72% of total taxonomic richness (figure-2). Aquatic insects comprise a taxonomically diverse and ecologically important and interesting group of animals in lentic fresh water systems[20].

Total density analysis is characterized by a large amplitude variation (figure-3), showing a peak in June 2007 in relation with a clear dominance of Ostracoda crustaceans. Community structures prove a relative fluctuation of the density due to dominance by three taxa respectively *Mercuria confusa*, Ostracods and *Echinogammarus pungens* which present between 80% and 95% from the total macrozoobenthos sampled.

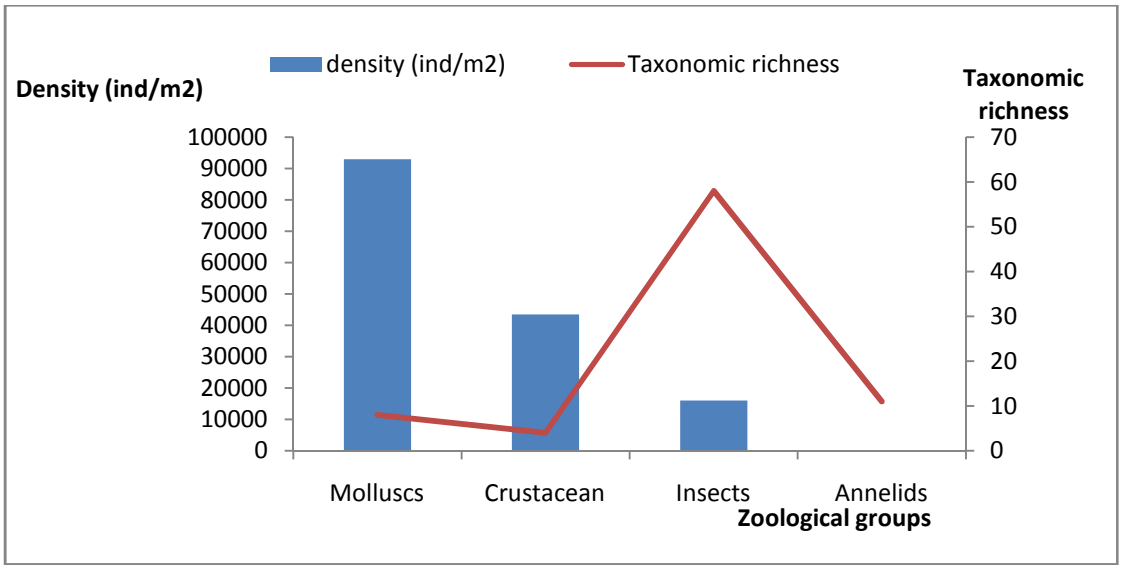

Figure-2
Qualitative and quantitative distribution of the different zoological groups in hydrographic basins

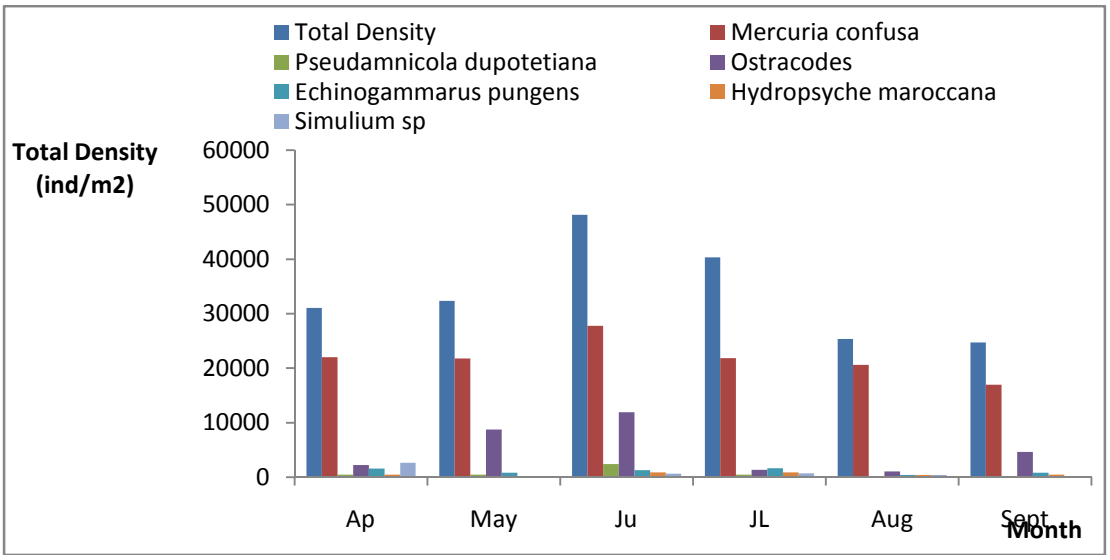

Figure-3
Temporal evolution of the benthic population and dominant taxa in hydrographic basins

Taxonomic richness and total density show a large spatial variability (figure-4). As for the stations, they are dividable into two categories under the influence of the upstream–downstream gradient: i. Firstly, group 1 comprises stations located on the Medjerda river (ST1, ST2 and ST3) where there is a large density and taxonomic richness respectively exceeding 8306 ind / m² and 25 taxa. ii. Secondly group 2 represents stations in the watershed Joumine (ST4, ST5 and ST6) where density could reach significant values (over 5000 ind / m²) while the taxonomic richness was significantly lower (≤ 25 taxa) than that recorded in the first group.

A Shannon diversity index (H') varies between 0.23 bits (ST3) and 2.82 bits (ST4). So, at the stations ST2, ST3, ST5 and ST6, values of the index of Shannon-Wiener are very low (H' <1,07 bits) and show an imbalanced fauna (J' <0.23 bits). The high abundance of Ostracods at ST 2 and ST6, *Mercuria confusa* at ST3 and *Echinoammarus pungens* at ST 5 (Relative Abundance > 79%) explains this low diversity and the significant imbalance of benthic fauna . In ST1 and ST4, values of biotic indices offer a larger number of microhabitats, caused either by their larger size, or by particular habitat conditions (different substratum types, vegetation, etc.). That fact enables the colonization of many species, each represented by a low density (H '> 2.63 bits) stressing an equilibrium of benthic communities (0 55 < J' <0.63) (table-2).

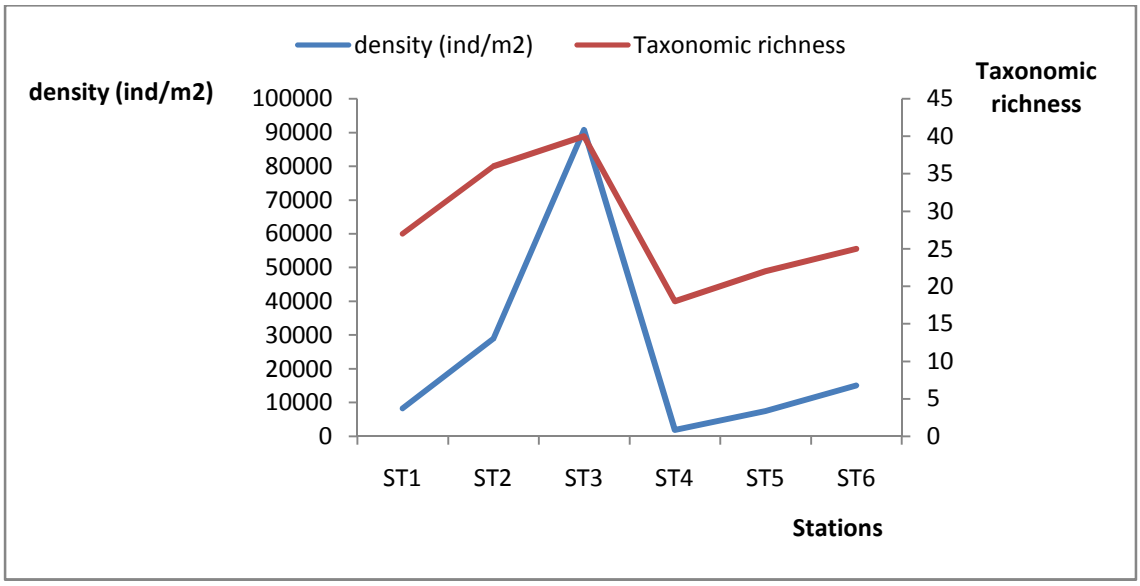

Figure-4
Spatial Evolution of taxonomic richness (RT) and density (D) of benthic macrofauna in hydrographic basins

Table-1
Habitat characteristics of sampling stations

	Medjerda (ST1)	Chafrou (ST2)	Khlaidia (ST3)	Bajer (ST4)	Tout (ST5)	El Mouajel (ST6)
GPS Coordinates	36°48'30,37''N 9°50'55,85''E	36°50'01,52''N 9°56'55, 55''E	36°57'02,24''N 10°05'05,58 ''E	36°52'888''N 9°36'083''E	36°52'776''N 9°30'550''E	36°54'268''N 9°31'248''E
Altitude (m)	28	17	5	140	371	385
Width (m)	40	4,25	4,5	1,5	2,5	2
Depth (cm)	30	43	5	7	2	10
Mean Current velocity (cm/s)	32,30	40,86	35,86	31,63	8,34	10, 18
Mean temperature of water (°C)	23,5	22,25	21,66	20,16	20	19,62
Mean Turbidity (NTU)	125,5	45	18	321,66	601,66	90,6
Mean Salinity (PSU)	1,63	4,03	5,18	0,23	0,1	0,1
Mean Conductivity (µs/cm)	3125	7045	8910	986	664	611
Mean pH	7,8	7,6	7,7	7,7	7,8	7,46
Type of substrate	Rocks, stone and sand	Muddy	Muddy-Silty	Clay and Muddy	Muddy	Sandy silty, Galets and Gravels
Vegetative cover	Apiaceae Chlorophyceae Myrtacea Poaceae Ranunculacea Tamaricaceae	Apiaceae Asteracea Chlorophyceae Juncaceae Poaceae Tamaricaceae	Chlorophyceae Lemnaceae Poaceae	Gentianaceae Lamiaceae Poaceae	Apiaceae Amaryllidacea e Lamiaceae Lythraceae Poaceae	Apiaceae Brassicaceae Cyperaceae Geraniaceae Rosaceae

Table-2
Diversity values of the six stations sampled (N: Total effective; TR: Taxonomic richness; H ': Shannon diversity index (in bits); J': Pielou evenness

	ST1	ST2	ST3	ST4	ST5	ST6
TR	27	36	40	18	22	25
N	6644	23157	72649	1548	6023	12119
H' (bits)	2,63	1,07	0,23	2,82	0,95	0,74
J'	0,55	0,20	0,043	0,63	0,23	0,16

In order to complete the quantitative analysis so as to explain the relations between the selected environmental variations and the various taxa sampled, Principal Component Analysis (PCA) was used with 72.7% of the total variance retained by the two first axes.

The results of the PCA analysis are shown in figure-5. Principal component 1 explained 41.6% of variation, and was associated primarily with three stations in each watershed: Medjerda (ST1, ST2 and ST3) and Joumine (ST4, ST5 and ST6), indicating that component 1 is a hydrographical grouping of two different networks according to a similarity of 32.5%. Principal component 2 explained 31.1% of the variation did not reveal any significant grouping, since cloud structure on PC1-PC2 has a bell shape, with a good ordination on axis PC1. However, this axis can separate ST1 that is located on the river Medjerda (large width of the bed, near-constant speed, relatively turbid water, a dominantly coarse substrate) from the two other stations ST2 and ST3 (clear, mineralized water and muddy substrate).

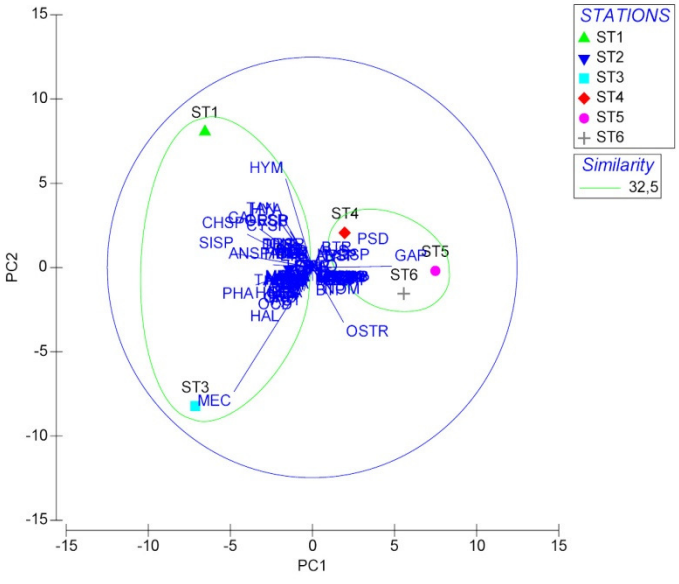

Figure-5
Distribution of taxa collected and grouping of stations according to Bray-Curtis similarity (32.5%) in PC1-PC2 plan.

The investigated habitats showed the existence of a benthic fauna common for freshwater environments with mainly insects, crustaceans, molluscs and annelids.

In fact, average density of benthic organisms varies in the sampling stations up to very high values, especially in Khlaidia river (ST3) (90818,75ind / m2), and this variation is clearly linked according [21] to the presence of aquatic vegetation, used for shelter and as source of organic matter. The low density recorded at Bajer river (ST4), 1897ind / m², is an indicator of their structural and hydrological particularities (hardly dense vegetation cover, a compact muddy substrate, small and shallow water course). Thus, Community composition is closely related to habitat specificity. *Hydropsyche maroccana* is the most present species of the investigated communities, suggest a hypothesis that it controls, as a predator, other groups at relatively low densities. On the other hand, the presence of some taxa of the same trophic group mainly represented by two grinders Ephemeroptera; *Caenis luctuosa* and *Baetis pavidus* raises the possibility of a competitive exclusion for *Caenis luctuosa*. Indeed, the abundance of *Baetis pavidus* was significantly lower throughout study period.

The study of biodiversity through biotic indices, including taxonomic richness and diversity indices (H' and J'), described an ecosystem on the basis of indicators of the state of diversity of biota[22].

The results obtained from taxonomic richness analysis are showing slightly higher values for larger areas corresponding to Medjerda (ST1, ST2 and ST3) which 40 taxa identified in Khlaidia river (ST3), compared to the values found at the small streams of Joumine (ST4, ST5 and ST6), with a maximum of 25 taxa collected at Bajer river (ST4) (table-2), a fact that leads to the conclusion that most benthic species are well adapted to particular habitat conditions. This idea is also sustained by cluster analysis: larger sites tend to be more heterogeneous, offering a larger number of ecological niches, therefore hosting a larger number of species and individuals.

On the contrary, homogenous habitats tend to have a lower number of species because of the specific habitat requirements of most species: presence and type of vegetation, substratum consistence and water flow speed [2]. Such sites are usually small ones. This state is characteristic of epirhithral biotope, near the very few productive sources[23].

Following Shannon diversity index (H'), which was very low in some stations, this parameter indicates an imbalance in the structure of benthic communities.

The influence of habitat characteristics on biodiversity values is very low at ST2, ST3, ST5 and ST6 and this reflects the dominance of a small group of taxa, which approaches this population of disturbed areas [24].

Direct assessment of health status of a freshwater environment will integrate the method of ecological groups and biotic indices in the bio-assessment of benthic structures and its spatial distribution by controlling the physicochemical quality of the water. According to a similarity of 32.5%, the first three stations gather on PC1 but ST1 station separates on PC2. This separation emphasizes both the anthropic impacts from the cities of El Batan and Tébourba and the hydrological characteristics of this station, such as current velocity or annual fluctuations of the water level which are also of great importance, influenced by the amount of sediments, especially organic. While the two other Chafrou and Khlaidia tributaries drain mainly from /into agricultural areas. Indeed, the physical and chemical environment shapes community structure of an ecosystem[25]. Characteristics of water bodies influence the quality of water individually and also in combination with various pollutants5. Urbanization and industrial activities have done much harm to the natural and aquatic environment[26].

If we look at the three other stations (ST4, ST5, ST6), upstream watershed of Joumine river, in opposition to the three first stations on the first axis (PC1) defined by co-inertie analysis we see a clear separation between two biotopes (ST5 and ST6) which are very close in source, as classified by Quadros Goldin [27] and the station (ST4) which is localised further downstream of Bajer river that is characteristic of meso-rithral.

The results of the present study show a great potential from a point of view of the Taxa. Each station presents a different community structure. Indeed, *Hydropsyche maroccana* tends to dominate (40°/°) ST1 and ST4, and the dominance of this species is explained by a wide trophic spectrum in these rivers. Chafrou river (ST2) and El Mouajel river (ST6) which are occupied mainly by Ostracoda indicate clear shallow waters, a fact that is in accordance with observations of Sönmez N[28]. *Mercuria confusa* is the best adapted species in Khlaidia river (ST3). Its presence can be explained not only by its intrinsic invasive capacity but also by its acute tolerance to organic pollution, essentially agricultural (nitrogen fertilizers). These remarks were reported by Khalloufi N[29] in several other rivers such as the Oued Abid (Northeast) and Gabes (Southeast*). Echinogammarus pungens*, harvested mainly at Tout river (ST5) and El Mouajel river (ST6), is known for its preference of hard water flowing over limestone strata.

Conclusion

This ecological study in six oueds of North Est Tunisian including three belonging to the watershed Medjerda and three to the Joumine has provided new data on macrobenthic fauna for the first time e.g *Sigara* sp, *Parasigara* sp, *Nepa* sp and *Microvelia* sp (Heteroptera), *Orthotrichia* sp (Caddis) and *Hydraena scabrosa* (Beetle).

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