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## Structure and macroinvertebrate diversity in the Moulouya river basin, Morocco

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### Abstract

This study provides an update of the inventory of the benthic macrofauna based in sampling carried out in 16 sites in Moulouya river basin (Eastern region from Morocco) between March 2012 and April 2014. The result obtained show that qualitative analysis of the macrozoobenthos allowed the identification of 10120 individus including to 173 taxa: 65% insects belonging to 7 Orders (Ephemeroptera, Plecoptera, Heteroptera, Coleoptera, Trichoptera, Odonata and Diptera). The faunistic list identified in this paper has enriched the Moulouya basin biodiversity, by 11 species previously unknown are. The ecological analysis communities allowed to identify, the least number of species was observed in superior zones of the rivers areas. However, the highest number of species was recorded in lowland areas.

**Keywords:** Diversity, macrofauna, Moulouya river basin, Morocco

### 1. Introduction

Due to its geographical position, Morocco represents a contact area between several regions such Southern Europe and Africa. Its importance as a compulsory passage area for much of the fauna between the Palaearctic and Afrotropical regions, gives it a particular interest for faunistic, ecological and biogeographical studies. If the invertebrate fauna of aquatic ecosystems in Europe is generally well known, gaps remain in Morocco where research on this fauna were limited in time and space.

In addition, this fauna is extremely diverse both in terms of taxonomic groups and in terms of species richness. Currently, the knowledge of benthic macroinvertebrates in rivers concern Moroccan naturalists and scientists charged in the development<sup>[1]</sup>. This interest because is the Moroccan benthic fauna offer by its richness and diversity of the broader fields of investigation, However, this benthic fauna are important elements in the ecological dynamics of river ecosystems and have been widely used as biological indicators of water quality and playing an important role in the cycle of materials and in trophic transfers<sup>[2,3,4,5]</sup>. Benthic macrofauna are well represented in aquatic environments and constitute a significant percentage of the total biodiversity and abundance<sup>[6]</sup> and are commonly used in toxicological studies<sup>[7,8]</sup>. The aquatic fauna offer many advantages as biomonitors, they are ubiquitous, and the large volume of species offers a spectrum of responses to environmental stresses<sup>[9]</sup>.

The Moulouya River is one of the big Moroccan rivers and is well studied with regard to the benthic macroinvertebrates<sup>[10-14]</sup>. The aim of the present work is to study the species diversity and distribution of benthic macroinvertebrates in Moulouya river basin.

### 2. Materials and Methods

#### 2.1 Study Area

Our study area focusses on the Moulouya River one of the largest permanent rivers in Morocco. The Moulouya River (Figure 1) is the main watercourse located in north-eastern Morocco between 36-39° N and 5-7° W, with a catchment area that covers 53 500 km<sup>2</sup><sup>[15]</sup>. It originates in the Atlas Mountains at an altitude of 1770 m and flows into the Mediterranean Sea. The river receive two mountain tributaries (the Oudghes and Anzegmir) Then turn the Melloulou and Za; two deductions dam (Mohamed V and Mechra - Homadi) are located before the embouchure<sup>[16]</sup>. Within the Moulouya catchment the climate is Mediterranean arid to semi-arid, with an average precipitation ranging from 200 mm in the lowlands and up to 500 mm in the Atlas Mountains and most of the rainfall is concentrated in only a few days, leading to high fluctuations in water discharge<sup>[17-19]</sup>.

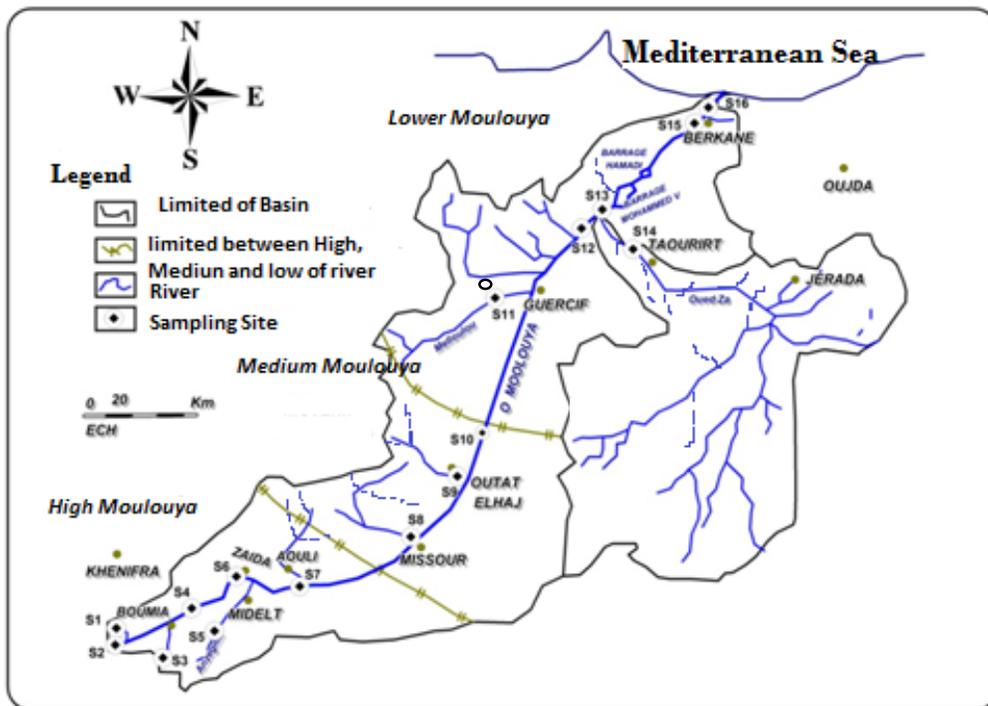


Fig1: Location of the sampling sites in Moulouya River Basin

**2.2 Macroinvertebrate Sampling**

Sixteen sampling stations (S1-S16) were chosen along the river basin. Collection of fauna was performed from March, 2012 to April, 2014, using a Surber and Havan sampler. The samples were brought to the laboratory and passed through 3 sieved of 2mm, 1mm and 0.5mm mesh sizes to collect the benthos. They were then identified under a compound binocular microscope using the key guide of [21-23] and counted. The identified species are preserved in 70% alcohol.

**3. Results**

**3.1 macrofauna biodiversity**

The fauna recorded in this work is composed of a total of 10120 individus including to 173 species. 65% are insects belonging to 7 Orders (Ephemeroptera, Plecoptera, Heteroptera, Coleoptera, Trichoptera, Odonata and Diptera). These species are distributed on 64 families. Various macrobenthic invertebrate taxa encountered at the different sampling stations are presented in Table 2. While the illustration in Figure 2 shows the percentage composition of macrobenthic invertebrates' phyla of Moulouya.

Table 1: Composition of benthic macroinvertebrates encountered in Moulouya River Basin

Classe	Ordre	Number of Famille	Number of Taxa	Number of Individual specie
Mollusca	Gasteropoda	7	11	567
	Bivalvia	1	1	213
Crustacea	Decapoda	1	1	375
	Amphipoda	1	1	395
	Isopoda	1	1	312
Annelida	Acheta	2	3	107
	Oligochaeta	4	6	520
Insecta	Diptera	5	13	950
	Trichoptera	12	44	1773
	Heteroptera	5	5	745
	Odonata	2	2	598
	Dermoptera	1	1	395
	Coleoptera	10	51	1994
	Ephemeroptera	5	17	831
Plecoptera	7	16	345	
Total		64	173	10120

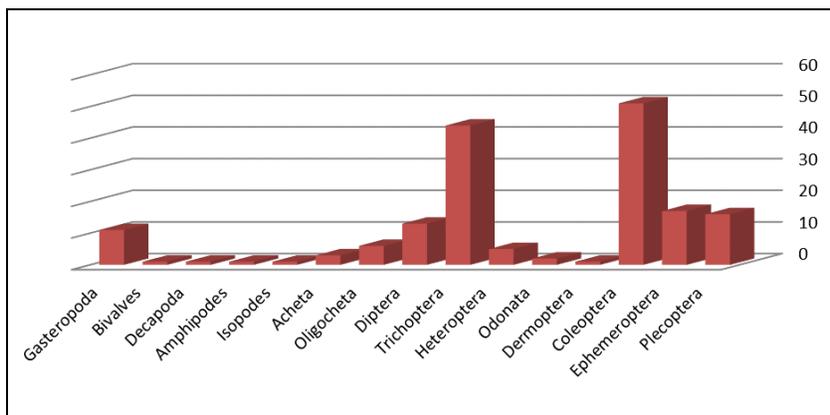


Fig 2: Benthic macroinvertebrates collected in Moulouya River Basin

Relative abundance of macrofauna presented in the figure 3 show that 86.12% of species identified are insects followed by mollusca (6.93%), annelida (5.20%) and crustacea (1.73%).

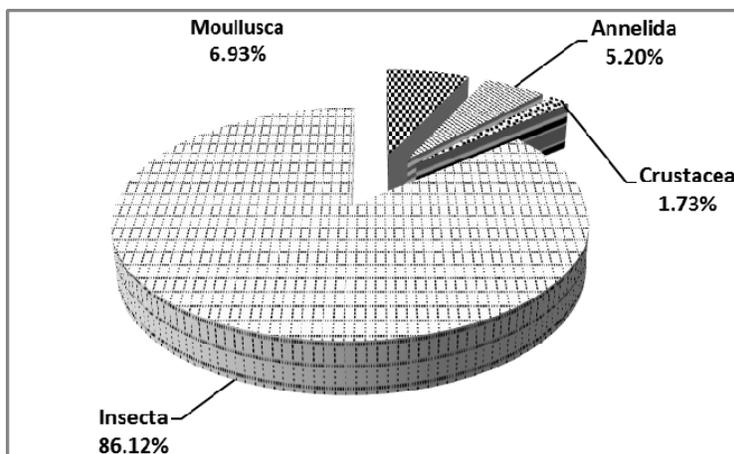


Fig 3: Relative abundances of the faunistic groups investigated in Moulouya River Basin

All the stations were dominated by insects, represented mostly by 8 orders: Ephemeroptera, Odonates, Plecoptera, Heteroptera, Beetles, Trichoptera and Dipterans. Orders of Planipenna, Megaloptera and Hymenoptera were not

encountered in this investigation. However, Beetles (34%) and Trichoptera (30%) are the orders the most diversified with respectively 51 and 44 taxa (Figure 4 and Table 1).

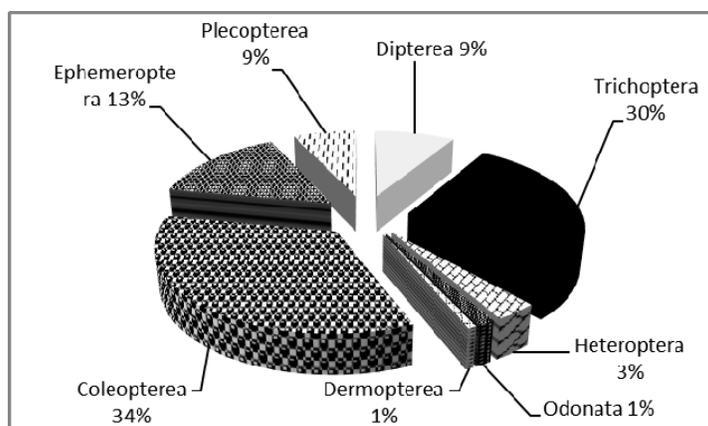


Fig 4: Relative percentages of the various orders of aquatic insects

The following patterns can be described for the first time in Moulouya river basin: *Hygrobia hermanni* (Herbst, on 1779), *Prasocuris glabra* (Herbst 1783), *Rhanthus hispanicus* (Sharp, on 1822), belonging to Beetles, and *Agapetus beredensis* (Dakki and Malicky, on 1980), *Hydroptila angulata* (Mosely, on 1922), *Ecnomus tenellus* (Rambur, on 1842), *Ecnomus relictus* (Brave, on 1953) belonging to Trichoptera. On the other hand, Orders of the fauna represent 36% of the insect's population identified in Moulouya

area. Plecoptera (9%) is represented by 13 species. Indeed, *Leuctra vaillanti* (Aubert, on 1956), *Protonemura tyrrhena* (Festa, on 1938) and *Protonemura algirica* (Aubert, on 1956) are not mentioned previously in this study area. Odonata and Dermaptera represented by 1%, and they included they constitutes the small representative order, (*Coenagrion sp*; *Cordulia sp*) and (*Libidura sp*) were considered as minority organism collected in this area (Table 2).

Table 2: Inventory faunistic of the Moulouya river basin

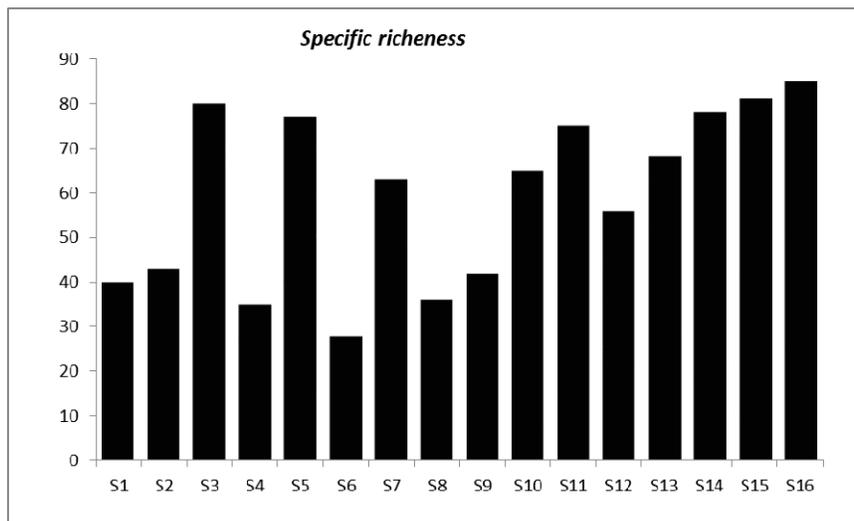
Diptera	<i>Prodiamesa Olivacea, Volucella pellucens, Tanypody sp, Tabanus sp, Psychoda severini, Culicoides sp, Simulium sp, Hetacnephia blanco</i>
Trichoptera	<i>Hydropsyche fezana, Hydropsyche pellucidula, Hydropsyche resmineda, Hydropsyche maroccana, Hydropsyche lobata, Chimarra marginata, Hydropsyche obscura, Hydroptila vectis, Hydroptila campanulata, Hydroptila engulata, Hydroptila cintrana, Ithytrichia clavata, Oxyethira falcate, Oxyethira unidentata, Orthotrichia costalis, Orthotrichia angustella, Allotrichia pallicornis, Pseudoneureclipsis maroccanus, Plectrocnemia geniculata, Cyrnus maroccanus, Plectrocnemia laetabilis, Polycentropus kingi, Micrasema moestum, Ecnomus deceptor, Ecnomus tenellus, Ecnomus relictus, Rhyacophila munda, Rhyacophila fonticola, Philoptamus ketma, Chimarra marginata, Agapetus beredensis, Agapetus dolichopterus, Agapetus incertulus, Mesophylax asperses, Stenophylax vibex, Stenophylax mitis, Stenophylax curvidens, Allogamus mortoni, Mystacides azurea, Leptocerus maroccanus, Leptocerus tineiformis, Psychomyia pusilla, Tinodes algiricus, Silonella aurata</i>

Heteroptera	<i>Nepa sp, Corixa affinis, Hydrometer sp, Notonecta sp, Microvelia sp</i>
Odonata	<i>Coenagrion sp, Cordulia sp</i>
Dermoptera	<i>Labidura sp</i>
Coleoptera	<i>Hygrobia hermanni, Haliplus sp, Aulonogyrus striatus, Gyrimus dejeani, Gyrimus caspius, Nebrioporus clarki, Deronectes theryi, Hydroporus obsoletus, Agabus bipustulatus, Agabus didymus, Dytiscus pisanus, Agabus brunneus, Agabus nebulosus, Graptodytes aequalis, Meladema coriacea, Laccophilus minutus, Rhanthushis panicus, Hydroglyphus geminus, Orectochilus villosusbellieri, Laccobius gracilis, Laccobius atrocephalus, Laccobius sinuatus, Laccobius ytenensis, Anacaena bipustulata, Anacaena globulus, Anacaena lutescens, Berosusaffinis, Coelostoma hispanicum, Riolus cupreus, Oulimnius fuscipes, Oulimnius villosus, Oulimnius maurus, Elmis maugetiivelutina, Normandia substriata, Limnius intermedius, Stenelmis consobrina, Hydraena narigua Hydraena africana, Ochthebius quadrioveolatus, Ochthebius tacapasensis, Ochthebius maculatus, Ochthebius mediterraneus, Hydraena africana, Hydraena allomorpha, Limnebius fretalis, Limnebius kamali, Prasocuris glabra, Helichus sp, Dryops sulcipennis, Dryops gracilis, Helophorus aquaticus, Helophorus algiricus</i>
Ephemeroptera	<i>Baetis pavidus, Baetis rhodani, Baetis neglectus, Baetis iberi, Centropilum pennulatum, Cloeon dipterum, Rhithrogena sp, Ecthyonrus rothschildi, Ecthyonrus forcipula, Caenis luctuosa, Brachycercus sp, Oligoneuriopsis skkounate, Paraleptophlebia cincta, Habrophlebia fusca, Habroleptoides modesa, Choroterpes picteti, Choroterpes lindrothi</i>
Plecoptera	<i>Isoperla sp, Hemimelaena flaviventris, Perla marginata, Eoperla ochracea, Leuctra maroccana, Leuctravallanti, Leuctra geniculata, Brachyptera algirica, Brachyptera auberti, Protonemura tyrrhena, Protonemura talboti, Nemoura rifensis, Protonemura algirica, Siphonoperla lepineyi, Capnioneura petitepierra, Capnia nigra</i>
Mollusca	<i>Planorbis sp, Physa acuta, Lymnaea peregra, Gyraulus laevis, Ancylus fluviatilis, Pisidium casertanum, Melanopsis praemorsa, Melanopsis cariasus, Melanopsis costellata Margaritifera margaritifera, Unio sp</i>
Acheta	<i>Erpobdella sp, Glossiphonia complanata, Helobdella stagnalis</i>
Oligochaeta	<i>Eiseniella tétraèdra, Dendrobuna suberubicunda, Tubifex tubifex, Lumbriculida sp, Nais communis, Nais pardalis</i>
Crustacea	<i>Gammarus gouthieri, Asellus aquaticus, Atyaephyra desmaresti</i>

**3.2. Specific richness**

In Moulouya upper (high altitude), taxonomic richness in mountain sources is important, with 42 taxa were collected in site (S2). In comparison with stations (S4) and (S6), the richness specie is very important in Oudghes tributary (S3) and in Anzegmir tributary (S5), whose recorded values are

respectively 80 and 77 taxa. In middle Moulouya, this taxonomic richness decreases sharply in Missouri and Outat El Haj agglomeration (S8 and S9). However, very high values of taxonomic richness are reported in lower Moulouya (S10 to S15) (Figure 5).



**Fig 5:** Variation of specific richness in Moulouya River Basin

**4. Discussion**

The present study aims enriched the fauna list of Moulouya river basin. Indeed, the macro-invertebrates of this river system are remarkable by their originality and their endemic Moroccan species [23], in particular: *Ecdyonurus rothschildi, Hydropsyche maroccana, Hydropsyche resmineda, Nebrioporu sclarki, Hydraena rigua, Normandia villosocostata.*

This benthic fauna is marked by the rarity of Plecoptera. The absence of this Order in certain water course of North Africa seems to be due to the high temperatures dominated on summer season. Several works [24-26] mentioned that the presence of Plecoptera limits itself in waters course oxygenated of the high altitude, and could also be due to

sectors characterized by abundant vegetation which monitors the physical conditions of the aquatic environment by the supply of nutrients and organic debris [27]. Indeed [28] showed that the abundance of Plecoptera along an Algerian river was connected to the importance of the ripisylve. Despite extensive investigation by a number of workers in this field, the absence of Planipenna and Megaloptera is to be noted. It is characteristics of water course fauna because the conditions in certain streams of high altitude are compatible with the ecological requirements of these orders [7-13].

Besides, No representative of the orders of Planipenna, Megaloptera or Hymenopterans were observed, which is not surprising because these three orders contain some aquatic species.

Also, The macrofauna of the Moulouya basin characterized by autochthonous elements, according to [29] these elements are known mostly in Mediterranean western *Eoperla ochracea*, *Siphonoperla lepineyi* (Plecoptera), *Silonella aurata* (Trichoptera). This fauna has some taxa that are part of typical African lineages (*Oligoneuriopsis skkounate*, *Ecnomus deceptor*, *Nebrioporus clarki*, *Hydroporus obsoletus*, *Laccophilus minutus*, *Prodimmaesa olivacea*, *Volucella pelluteus*) and oriental (*Haliplus sp*, *Simulium sp*).

Mediterranean Europe clearly appears much richer than North Africa, as well in number of species and number of endemic, This is mainly explained by the history of this country [29-31].

Recent studies at the regional level [32-39] highlighted the low macrofauna diversity in continental ecosystems in North Africa. Indeed, most of the families and genres are poor in specie: Baetidae, Heptageniidae, Perlodidae, Perlidae, Chloroperlidae, Capniidae, on the other hand, this fauna present an important taxonomic variety in Europe. The important reduction in this diversity is due to high temperatures than in Europe.

In the order Ephemeroptera, the family Heptageniidae was presented with the greatest number of species, but the most numerous species were *Baetis rhodani* and *Rhithrogena sp*. the number of recorded benthic macroinvertebrates population was generally low because of some ecological factors arising from alterations of some important factors governing the abundance and distribution of the benthic communities.

Analysis of ecological communities allowed to identify, the upper Moulouya area influenced by remarkable diversity of macroinvertebrate, this site was characterized by a high number of stenothermal species and sensitive of pollution such as Plecoptera, in contrast, Ephemeroptera, Trichoptera, Beetles and Diptera were the most greater organism collected in low mountain [30, 31].

The faunistic list established in this study conducted quantitatively 173 taxa observed in this study exceeded that observed on other parts of Moroccan streams area. 167 taxon collected in wild Target [40], 124 in wadi Boufekrane [38]. In contrast 60 species recorded in the wadi khoumane [39], and only 53 species in wadi Ourika [41].

## 5. Conclusion

This research work constitutes a contribution to the knowledge of the aquatic macrofauna populate the river of Moulouya. Indeed, it is characterized by a specific diversity of the aquatic populating; he accommodates a total of 173 species belonging to the Palearctic zone with endemic Moroccan species from the Maghreb. It is certain that this list is not still exhaustive. Discoveries of new species for Morocco are still waited. Benthic macroinvertebrates were recommended followed researches for evaluations of environmental impact and in biomonitoring.

## 6. Conflict of interest

The authors declare that they have no conflict of interest.

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