



## Biodiversity and distribution of freshwater molluscs in superficial waters of Ouergha watershed (Morocco)

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### Abstract

The primary goal of this work was to establish the specific biodiversity of freshwater molluscs in aquatic environments of Ouergha watershed. This faunal inventory fills the gaps in inventories malacological of Morocco especially the malacofauna of high altitudes. The missions surveys conducted between 2002 and 2005 show that the species found in the catchment area belong mostly to the class of gastropods. Indeed, among the 40 surface freshwater molluscs known in Morocco, 20 species have been recorded including two potential taxa : *Planorbis* *Planorbis* and *Gyraulus laevis*. The species inventoried are divided into 10 families: two families of Prosobranchia, six families of Pulmonata and two family of Bivalvia. The subclass Pulmonata has the most species (10 species) followed by Prosobranchia (5 species ) and Bivalvia (4 species). The presence of *Lymnaea maroccana*, endemic species of Morocco, was confirmed in ponds of Annasser. Biotic and abiotic factors are the most controlling the distribution of aquatic in the study area. Those factors are speed of water current, nature of the substrate and abundance of aquatic plants.

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## Introduction

The systematic of freshwater molluscs of Morocco was revised in 1998 by Ghamizi. He identify 82 groundwater and superficial species. However, faunal research dedicated to this group in medium and high altitudes conducted right now are reduced and confined to the work of Bouka (1993) on the Middle Atlas Mountains. The choice of this watershed to study biodiversity and ecology of freshwater molluscs was prompted by several reasons. Indeed, the catchment area of Ouergha provides a great variety of continental aquatic environments. Those water body have the characteristic to be less affected by pollution who suffered most of the hydrological basins of the country. So it is easy to carry out studies in natural populations who are not submitted to the aggressions of pollution.

Furthermore, the basin supports the largest dam in the country (2nd in Africa). Generally, large hydraulic structures and the creation of retention lakes have significant effects on the environment since they introduce immediate changes in the natural landscape. The unpleasant surprises often caused by these projects are the result of lack of the preliminary studies in field ecology prevention. In this case, species of freshwater molluscs can be introduced with construction of new hydraulic structures. Some species of them are considerate as an intermediate hosts of some parasitic diseases of humans and livestock such as schistosomiasis, fascioliasis and paramphistomosis.

The description of aquatic environments in Ouergha watershed has focused on 39 selected stations during surveys carried out between september 2002 and december 2005. The choice of these stations was based on the molluscan data available, species diversity in each station, proximity of human settlements and the maximum coverage area of the watershed. Stations selected belong to various hydrological facies fresh and brackish water, standing and running-water ecosystems, temporary

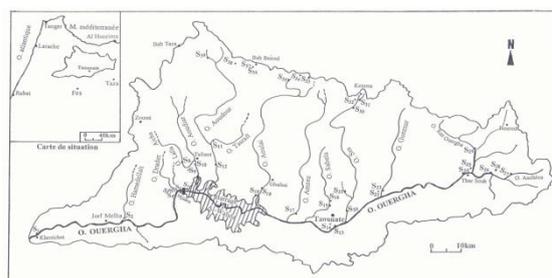
and permanent-water ecosystems. They include different types of continental aquatic environments such as rivers, creeks, streams, ponds, dams and sources.

Therefore, we contribute by the present labor to establish a comprehensive inventory of the superficial freshwater molluscs in the catchment area of the Ouergha river. Our study will certainly promote the integration aquatic molluscs as essential tools in fundamental and applied research of environmental surface waters. That study will also fill the gaps in the field of malacological inventories of water body in Rif mountains.

## Materials and methods

### The study area

The basin area of Ouergha river is located in north of Morocco between  $34^{\circ} 20' \sim 35^{\circ} 10'$  north latitude and  $3^{\circ} 50' \sim 5^{\circ} 30'$  west longitude. Elevations of mountains are between 100 and 2450 m. The total area of the catchment is 7325 km<sup>2</sup>. This watershed is set on the southern slopes of the Rif arch mountain chain of Alpine orogeny. In the northern region of the basin, are located the largest number of high ridges of the Rif chain whose high altitude exceed 2000 m. The morphology of the basin is characterized by a relief that contains very strong slopes, a fundamental factor in *erosion* susceptibility.



**Fig. 1.** Location of the sampling stations in Ouergha watershed.

The climate of the basin is mediterranean type ranging from *suhumid* to *semi-arid*. In these bioclimatic zones are linked different stages of

vegetation that are largely related to the altitude. Al-Wahda Dam is situated in the basin of the Ouergha with the retention capacity over than 3,700 million m<sup>3</sup>. It is the largest dam in Morocco that can protect Gharb plain against floods and can irrigates 100,000 hectares in the the same plain.

Thirty nine (39) stations were selected at the area of study (Fig. 1). The choice was founded on malacological data available, specific diversity of freshwater molluscs in each station, the proximity of human settlements and finally the coverage of the maximum area of the catchment. These selected stations integrate different kinds of continental aquatic environments from rivers to temporary ponds.

At each sample, we measured or estimated the following environmental parameters (Table 1) : Altitude, the type of water body, width of the water body in beginning of summer, maximum width of the water body, water depth, speed of water current, nature of the substrate, presence of filamentous algae, Abundance of aquatic plants.

#### Sampling methods

##### Sampling by Surber sampler

This method was used in rivers and springs. The Surber sampler consists of two interlocking frames that support a capturing net. One frame outlines the area of stream bed to be sampled while the other supports the net. The sampler is intended for use in shallow (30 cm or less) flowing waters. We used a colander square (32 cm square).

which is fitted with a mosquito net of 0.8 mm mesh size. The principle consists in scraping the bottom within the area bounded in front of the filter surface. The fauna stopped by strainer is recovered and taken for identification.

##### Quadrat method

The quadrat method has been widely used in plant and faunal studies. A quadrat is a four-sided figure

which delimits the boundaries of a sample plot. Quadrat sampling involves counting all individuals within a known area (or volume). Since density ( $D$ ) and population size ( $N$ ) are related, as  $N = D \times \text{area}$ , we can estimate the density for the sample and from this compute the total population.

##### Visual search

Visible species are taken by hand. Hunting shall be performed during a delimited period between 15 to 30 minutes. The alternative is not to set a time and consider that the sampling is completed when the habitat was enough sampled.

#### Results

The purpose to establish the checklist of freshwater molluscs in the Ouergha watershed is to be a useful tool for the aquatic management in the area especially after the construction of the Al-Wahda Dam. The symbol [?] indicates that the species is potential in the basin where only empty shells were collected. Freshwater molluscs were identified until species by referring the proceedings of Germain (1931), Peres (1943); Hubendick (1951 and 1955), Adam (1960), Girod *et al.* (1980), Ghamizi (1998) and Falkner *et al.* (2001).

Phylum: Mollusca Cuvier, 1795

Class: Gastropoda Cuvier, 1795

Subclass: Prosobranchia Ponder & Lindberg, 1905

Superorder: Neritaemorphi Koken, 1896

Order: Neritopsina Cox & Knight, 1960

Superfamily: Neritoidea Lamarck, 1809

Family: Neritidae Lamarck, 1809

Subfamily: Neritidinae Lamarck, 1809

Genus: *Theodoxus* Montfort, 1810

-*Theodoxus fluviatilis* Linnaeus, 1758

Superorder: Caenogastropoda Cox, 1960

Order: Neotaenioglossa Haller, 1892

Superfamily: Cerithioidae A. Ferussac, 1822

Family: Melanopsidae H. & A. Adams, 1854

Subfamily: Melanopsinae H. & A. Adams, 1854

Genus: *Melanopsis* Ferussac, 1807

-*Melanopsis praemorsa* Linnaeus, 1758

-*Melanopsis scalaris* Gassies, 1856  
 -*Melanopsis costellata* Ferussac, 1823  
 Superfamily: Hydroboidea Giusta & Pezzoli, 1982  
 Family: Hydrobiidae Troschel, 1857  
 Subfamily: Hydrobiinae Troschel, 1857  
 Genus: *Mercuria* Boeters, 1971  
 -*Mercuria similis* Draparnaud, 1805  
 Genus: *Hydrobia* Hartman, 1821  
 -*Hydrobia maroccana* Pallary, 1921  
 Subclass: Pulmonata Cuvier, 1814  
 Superorder: Heterobranchia Gray, 1840  
 Order: Basommatophora Keferstein, 1864  
 Superfamily: Lymnaeidea Rafinesque, 1815  
 Family: Lymnaeidea Rafinesque, 1815  
 Subfamily: Lymnaeinae Rafinesque, 1815  
 Genus: *Lymnaea* Lamarck, 1799  
 -*Lymnaea truncatula* O.F. Müller, 1774  
 -*Lymnaea maroccana* Pallary, 1889  
 -*Lymnaea peregra* O.F. Müller, 1774  
 Superfamily: Planorbioidea Rafinesque, 1815  
 Family: Physidae Fitzinger, 1833  
 Subfamily: Physinae Fitzinger, 1833  
 Genus: *Physa* Draparnaud, 1801  
 -*Physa acuta* Draparnaud, 1805  
 Family: Planorbidae Rafinesque, 1815  
 Subfamily: Bulininae P. Fischer & Crosse, 1880  
 Genus: *Planorbarius* Froriep, 1806  
 -*Planorbarius metidjensis* Forbes, 1836  
 Subfamily: Planorbinae Rafinesque, 1815  
 Genus: *Planorbis* O.F. Müller, 1773  
 -*Anisus spirorbis* Linnaeus, 1758  
 -*Planorbis planorbis* Linnaeus, 1758 [?]  
 Genus: *Gyraulus* Charpentier, 1837  
 -*Gyraulus laevis* Alder, 1838 [?]  
 Family: Ancyliidae Rafinesque, 1815  
 Genus: *Ancylus* O.F. Müller, 1773  
 -*Ancylus fluviatilis* O.F. Müller, 1773  
 Suborder: Stylommatophora Schmidt, 1855  
 Superfamily: Succineoidea Beck, 1837  
 Family: Succineidae Beck, 1837  
 Subfamily: Succineinae Beck, 1837  
 Genus: *Succinea* Draparnaud, 1801  
 -*Succinea debilis* Morelet, 1845  
 Class: Bivalvia Linnaeus, 1758

Subclass: Eulamellibranchia Pelseneer, 1889  
 Superorder : Heterodonta Neunayr, 1884  
 Order: Veneroida H. & A. Adams, 1856  
 Superfamily: Sphaerioidae Deshayes, 1855  
 Family: Sphaeriidae Deshayes, 1855  
 Subfamily: Pisidiinae J.E. Gray 1857  
 Genus: *Pisidium* Pfeiffer, 1821  
 -*Pisidium casertanum* Poli, 1791  
 -*Pisidium personatum* Malm, 1855  
 -*Pisidium nitidum* Jenyns, 1832  
 Superorder: Palaeoheterodonta Neweell, 1985  
 Order: Unionoida Stoliczka, 1871  
 Superfamily: Unionoidea Rafinesque, 1820  
 Family: Unionidae Fleming, 1828  
 Subfamily: Unioninae Swainson, 1840  
 Genus: *Unio* Philipsson, 1788  
 -*Unio pictorum* Linnaeus, 1758.

Among the 40 freshwater molluscs known in Morocco, 20 species have been identified in the basin with two taxa are potential (*Gyraulus laevis* and *Planorbis Planorbis*). These species collected are divided into 10 families: 02 families Prosobranchia, 06 families of Pulmonate and 02 families of Bivalvia. Regarding species, the subclass of Pulmonata has the higher number of species (10 species) than Prosobranchia (5 species) and Bivalvia (4 species). The presence of *Lymnaea maroccana*, endemic species of Morocco, was confirmed in pools of Annasser which 13 species were collected.

In comparison with other structural formations surrounding the basin, Bouka (1993) listed 17 species of freshwater molluscs in the Middle Atlas mountains. Saoud (1995) identified 22 species in the Tangier Peninsula. According to our investigations in 1996, we collected 20 species in the Gharb plain. Kharboua (1988 and 1994) sampled 20 and 16 species respectively in the coastal plateau and eastern Morocco. 11 species have been recorded by Moukrim (1991) in the Souss valley and 9 species only Laamrani (1994) in the Tassaout plain.

**Table 1.** Abiotic records of 39 stations studied in the Ouergha watershed.

	Morpho-dynamic parameters					Substrate parameters				
	ALT (M)	TPE (CLASS)	LMO (M)	LMX (M)	PR (CM)	VC (CM/s)	SG (%)	SF (%)	AF (CLASS )	VA (%)
S <sub>1</sub>	15	4	30	52	312	48	20	80	1	0
S <sub>2</sub>	50	4	8	15	64	76	20	80	1	0
S <sub>3</sub>	90	4	8	11	52	84	60	40	2	30
S <sub>4</sub>	90	1	2	3,75	35	0	20	80	2	80
S <sub>5</sub>	90	3	3,5	6	38	15	40	60	1	10
S <sub>6</sub>	95	4	28	58	250	45	40	60	1	40
S <sub>7</sub>	120	2	>1km	>1km	>3 M	0	0	100	1	0
S <sub>8</sub>	185	4	8	12	87	69	50	50	2	10
S <sub>9</sub>	185	1	1,5	3,25	30	0	20	80	2	80
S <sub>10</sub>	210	4	13	22	83	72	60	40	1	20
S <sub>11</sub>	235	4	8	13	45	75	70	30	1	30
S <sub>12</sub>	209	4	14	25	72	82	70	30	1	30
S <sub>13</sub>	230	4	32	54	192	42	50	50	1	0
S <sub>14</sub>	230	3	2,75	5,5	29	55	60	40	1	0
S <sub>15</sub>	380	2	>1km	>1km	>3 M	0	0	100	1	0
S <sub>16</sub>	388	4	15	23	74	77	70	30	2	20
S <sub>17</sub>	225	4	12	19	82	64	70	30	2	30
S <sub>18</sub>	230	4	17	25	91	82	70	30	2	20
S <sub>19</sub>	225	2	>1km	>1km	>3 M	0	0	100	1	0
S <sub>20</sub>	370	4	15	24	78	69	70	30	2	30
S <sub>21</sub>	400	2	>1km	>1km	>3 M	0	0	100	2	0
S <sub>22</sub>	345	1	1,6	2,75	25	0	10	90	3	70
S <sub>23</sub>	345	4	11	23	38	75	70	30	2	20
S <sub>24</sub>	312	4	24	49	245	45	50	50	1	0
S <sub>25</sub>	850	1	2,8	3,5	23	17	10	90	1	0
S <sub>26</sub>	870	4	12	19	85	115	70	30	3	20
S <sub>27</sub>	760	2	>1km	>1km	>3 M	0	0	100	2	0
S <sub>28</sub>	920	3	2,75	5	34	110	70	30	3	60
S <sub>29</sub>	1100	4	11	18	52	98	80	20	4	10
S <sub>30</sub>	1600	4	8,0	15	31	124	90	10	4	10
S <sub>31</sub>	1600	3	3,6	6	36	159	60	40	1	0
S <sub>32</sub>	1600	1	1,0	4,2	61	25	80	20	4	60
S <sub>33</sub>	1345	1	1,0	4,7	58	21	90	10	4	60
S <sub>34</sub>	1350	1	1,0	5,2	57	29	90	10	4	70
S <sub>35</sub>	1150	4	8,0	15	33	125	90	10	3	10
S <sub>36</sub>	1200	2	84	120	234	0	0	100	4	70
S <sub>37</sub>	1200	2	42	65	125	0	0	100	3	80
S <sub>38</sub>	1200	3	3,5	6	23	140	60	40	2	0
S <sub>39</sub>	1150	4	8,0	15	24	130	90	10	4	30

**Discussion**

The distribution of freshwater molluscs in the area of study has revealed a close correlation between the distribution of molluscs and various typological facies prospected. Ecological exclusion between prosobranchs and pulmonata confirms that biotic and abiotic factors are the most controlling the distribution of aquatic in the study area. Those factors are speed of water current, nature of the substrate and abundance of aquatic plants. Mouthon (1980) stated that freshwater snails are able to assimilate different ecological situations, which contributes to the expression of their high degree of

eurytopy, pointed out by Hubendick (1958), Wolff (1968), Kefford and *al.* (2005), Strum (2007), Strong and *al.* (2008) and Saddozai and *al.* (2013).

The results of our sampling showed that the most common species in the region is *Physa acuta* which is present in almost all water bodies surveyed. This outcome is in agreement with those of Ramdani and *al.* (1987) and Ghamizi (1998). They indicated that the species is common in Morocco and can colonize all areas of continental water. The ability of *Physa acuta* to settle all types of freshwater habitats is linked to the reproduction system which is self-

fertilizing (Wethington and Dillon, 1993, 1996 and 1997; Jarne and *al.*; 2000; Facon and *al.*, 2006). This type reproduction allows to maintain reproduction during periods of colonization of new habitats after flooding or at recolonization of the biotope subject to ecological disturbances: drying, predation and alteration of same conditions of the environment (Henry and *al.*, 2005; Stockwell and *al.*, 2011).

The other eurytopic species sampled in the area of study is *Pisidium casertanum*. However, It is elective for type of substrates which are rich in organic matter. Kuiper (1966) noted that this species is widespread and can colonize temporary aquatic environments. Mouthon (1980) stated that the presence of many species of *Pisidium* is often linked to the presence of thick sediment deposits rich in organic matter. According to several authors, these small bivalves are able to withstand extreme conditions of pH and temperature (Kuiper and Wolff, 1970, Meier- Brook, 1975, Strum, 2007).

*Lymnaea truncatula* is also a species widely distributed in the biogeographical region studied. The densities of the species are higher in the permanent pool of Annasser and at river with high abundance of aquatic plants. Sampling of high density of the species in relatively temporary pond confirms that the species is gifted with high landfill capacity in the substrate.

*Ancylus fluviatilis* was sampled in almost every type of water body in the catchment , except in dams and ponds. According to Vala (1973) and Legier (1979), the species has a predilection for rivers and can colonizes rocky and rough substrate. It seems to be indifferent to the presence of aquatic plants. *Ancylus fluviatilis* was described by Ambhul (1959) as a species of running water.

*Unio pictorum*, *Melanopsis scalaris*, *Melanopsis costellata* and *Melanopsis praemorsa* are among the species characteristics of rivers of the basin. Those

taxa colonize clear waters in rivers, streams and rivulet especially those of low and medium altitudes.

*Hydrobia maroccana* and *Mercuria similis* were exclusively collected in sources with high concentrations of chlorides in water. *Hydrobia Maroccana* was also sampled by Ghamizi (1998) in stream water flow alimeted from the resurgence of sources. *Mercuria similis* was considered by Saoud (1995 ) as a tolerant species of high salt concentration (up to 10 ‰).

*Planorbarius metidjensis*, *Anisus spirorbis* and *Lymnaea maroccana* form an exclusive species group of the permanent pool of Annasser characterized by substrate rich with plant debris. The presence of a large number of exclusive species in this pond can be explained by the fact that the pool is mainly fed by groundwater of Annasser. Indeed, the water have high mineralization and low variations of seasonal temperature.

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