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Semi-quantitative analysis of freshwater molluscs in the permanent Annasser lakes, Ouergha watershed (Morocco)

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Abstract
The main goal of this investigation was to study the systematic, description and distribution of freshwater molluscs in the Annasser lakes located in the Ouergha watershed (Morocco). The semi-quantitative surveys carried out between September 2002 and December 2005 has focused on four selected stations in the permanent pond. The choice of these stations was based on the molluscan data available, physical structure of the pond, structure associated vegetation, species diversity in each station and the maximum coverage area of the pond. Nine species of freshwater molluscs were collected in the malacological survey. The specific diversity of aquatic snails are positively correlated with the heterogeneity and complexity of natural vegetation and type of substrate of the temporary pond. The physical structure of the permanent pond is recognized to have an important influence on the density and composition of species communities. Indeed, the species richness in those biotop increases with the heterogeneity of habitat, serving for protection against predators as well as the diversification of ecological niches that allow sharing of resources.

Keywords: Freshwater snails, systematic, distribution, Mountains lakes, Morocco.

1. Introduction
It is known that the distributions of some macroinvertebrates inhabiting ponds are related to concentration of particular chemicals and to physical variables such as temperature and pH [1]. Ecologically, molluscs constitute an important part of life in terrestrial and aquatic ecosystems [2]. As some are edible, many being agricultural pests or hosts to parasitic organisms, they have parasitological importance [3, 4]. In this context, each year, 200.000 deaths are associated with schistosomiasis which affect rural areas, but also the suburban and urban environments [5]. It is therefore a major health hazard, especially in Africa, where, under developments, lack of hygiene, persistent urinary and faecal peril, promote contamination.
Only little information is available on the ecology of aquatic freshwater molluscs of mountain lakes in Morocco. Scientific studies of the distribution of freshwater molluscs in the mountain lakes of Ouergha basin are still scarce, for two main reasons. First, colonization of mountain lakes and brooks is often limited to the very few species that can tolerate extreme environmental conditions. Second, abundances of such highly tolerant species in their aquatic biotopes are usually very low, which significantly complicates both their detection and quantification.
This study has two objectives. First, the present work aims to identify specific richness of malacological colonization of two important lakes of Ouergha watershed. Second, the study seeks to use some classic ecological descriptors in order to characterize and compare the description, distribution, functional structure and organization of population mollusk. These descriptors parameters are species richness, species diversity index, equitability, relative abundance, frequency, degree of preference and Jaccard index of similarity. Indeed, multivariate methods in ecology for Association-analysis use on equal the information provided on the mollusk population by homogenizing the taxonomic structure of the different facies. The use of autecological information is necessary to supplement the results obtained in the biotypological analysis.

2. Material and methods

2.1. The study area

The basin area of Ouergha river is located in north of Morocco between 34° 20 '~ 35° 10' north latitude and 3° 50'~ 5° 30' west longitude. Elevations of mountains are between 100 and 2450 m. The total area of the catchment is 7325 km^2. 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 exceeds 2000 m. The morphology of the basin is characterized by a relief that contains very strong slopes, a fundamental factor in erosion susceptibility**.**

The climate of the basin is a mediterranean type ranging from suhumid to semi-arid**.** In these bioclimatic zones are linked with 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^3. It is the largest dam in Morocco that can protect Gharb plain against floods and can irrigates 100,000 hectares in the same plain.

Pond of Annasser (Fig. 1) are the only existing important natural stagnant water bodies in the Ouergha basin. They are located 5 km west of Bab Berred city. The substrate is muddy, gravelly, rocky, sandy and muddy. Aquatic vegetation is composed by *Ceratophyllum demersum, Scirpus sp, Typha angustifolia, Juncus sp, Polygonum amphibium, Potamogeton pectinatus* and grasses.

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.

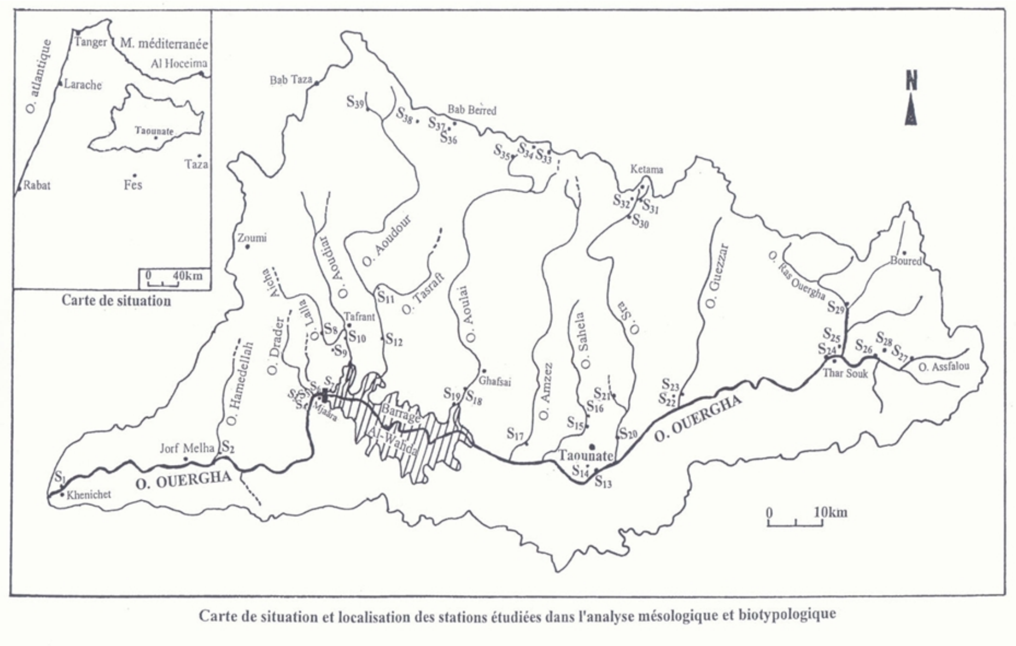

Fig 1: Location of the sampling stations in Ouergha watershed

2.2. Zonation of the permanent pool

The permanent pool was divided into four habitats depending on the nature of the substrate.

- Biotope P_1: gravelly substrate, rocky and without vegetation. Deep by 55 cm, partly considered as a source of feeding the pond.
- Biotope P_2: sandy, gravelly and without vegetation. Deep by 234 cm.
- Biotope P_3: muddy substrate, rich in plant debris with abundant aquatic vegetation. Deep by 72 cm,
- Biotope P_4: silty mud substrate with riparian vegetation. Deep by 28 cm.

The choice of stations was founded on malacological data available, specific diversity of freshwater molluscs in each biotope of the pond, the proximity of human settlements and finally the coverage of the maximum area. 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.

Table 1: Abiotic records of stations studied in the pond of Annasser

	Morpho-dynamic parameters						**Substrate parameters**			
	Alt (m)	TP (class)	LMo (m)	LMx (m)	Pr (cm)	VC (cm/s)	SG (%)	SF (%)	AF (class)	VA (%)
S_{36}	1200	2	84	120	234	0	0	100	4	70
S_{37}	1200	2	42	65	125	0	0	100	3	80

Legend table

Alt: altitude, **TPE**: type of water body (1-source, 2-dam or pond, 3-rivulet, 4-stream and river), **LMo**: width in beginning of summer, **LMx**: maximum width **Pr**: water depth, **VC**: speed of water current, **SG**: coarse substrate, **SF**: thin substrate, **AF**: filamentous algae (1-unnoticeable, 2-scarce, 3-abundant, 4-very abundant, **VA**: aquatic vegetation (1-no plants, 2-intermediate, 3-abundant density, 4-very abundant plant).

2.3. Sampling methods

2.3.1. 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.

2.3.2. 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 $N = D$ x area, we can estimate the density of the sample and from this compute the total population.

2.3.3. 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.

2.4. Expression of results

2.4.1. Species richness

Species richness is a fundamental measurement of community and regional diversity, and it underlies many ecological models and conservation strategies. It is defined by the number of species that includes in an ecosystem.

2.4.2. Index of species diversity

The index the most used is the Shannon-Wiener expressed by the following formula:

$$H = -\sum_{i=1}^{S} \frac{ni}{N} \log_2 \frac{ni}{N}$$

s: Total number of species present,
ni: number of individuals of the species rank "i"
N: total number of individuals.

The index of species diversity is high when the taxonomic richness is important and the distribution of individuals among taxa is balanced.

2.4.3. Equitability

Knowledge of species diversity index is used to determine equitability:

$$e = \frac{H}{\log_2 S} = \frac{H}{H'}$$

It varies between 0 and 1, tends to 0 as almost all species corresponds to a single species and tends toward unity when each species is represented by the same number of individuals.

2.4.4. Relative abundance

Relative abundance of a species is the percentage of the number of this species relative to the total number of individuals collected from a station. It is expressed by the following formula:

$$Pi = \frac{Ab\ (a)}{Ab\ (t)} \times 100$$

Où, Ab(a) : abondance absolue de l'espèce "a ",
Ab(t) : nombre total d'individus.

2.4.5. Frequency

The frequency of a species represents the percentage of samples where the species is present relative to the total number of samples. It is given by the following formula:

$$Fi = \frac{Pa}{Pt} \times 100$$

Pa: number of samples where the species "a" is harvested,
Pt: total number of samples. We adopt the proposed Vala [6]:

- Basic species: Pi> 10% and Fi> 50%
- Constant species: Pi <10% and Fi> 50%
- Companion species: 20 <Fi <50%
- Catch species: 5 <Fi <20%
- Sporadic species: Fi <5%.

2.4.6. Ecological preferences

The ecological preferences or degree of preference adopted Dakki [7]. Expresses the preference of species to a type of biotope. It is expressed by the formula:

$$d_{iJ} = 1 - \frac{S_i}{\log_2 J}$$

with:

$$S_i = -\Sigma \frac{n_{ij}+1}{\Sigma\left(n_{ij}+1\right)} \log_2 \frac{n_{ij}+1}{\Sigma\left(n_{ij}+1\right)}$$

- D_{iJ}: degree of preference of the species "i" in a sample of "J" habitats,
- N_{ij}: density of the species "i" in the habitat "j".

If the degree of preference of a species is high, its ecological niche is limited. If it is low, the species is little demand on the environmental factors and can perform its ecological niche in many habitats.

2.4.7. Jaccard index

It compares the common species in a biotop according to the following formula:

$$J = \frac{Pab}{(Pa + Pb) - Pab} \times 100$$

- *Pa:* number of species of the first survey "a",
- *Pb:* number of species of the second survey "b",
- *Pab:* number of species common to both surveys "a" and "b".

3. Results

3.1. Species richness

Nine species of freshwater molluscs were sampled in the four component biotopes of permanent pond of Annasser, they are:

- *Lymnaea truncatula*
- *Lymnaea peregra*
- *Physa acuta*
- *Planorbarius metidjensis*
- *Anisus spirorbis*
- *Ancylus fluviatilis*
- *Succinea debilis*
- *Pisidium casertanum*
- *Lymnaea maroccana*

Planorbarius metidjensis, Anisus spirorbis and *Lymnaea maroccana* are considered as exclusive species of the pond in the Ouergha watershed.

The physical structure of the pond is recognized to have an important influence on the density and composition of species communities. Indeed, the species richness in those biotop increases with the heterogeneity of habitat, serving for protection against predators as well as the diversification of ecological niches that allow sharing of resources [8, 9, 10]. Ghamizi [11] have been reported 40 superficial species of freshwater snail in Morocco.

3.2. Index of species diversity and equitability

The highest diversity index was noted in the P_4 biotope (H = 1.58) where the majority of the species present in the pond was harvested except *Planorbarius metidjensis* and *Lymnaea maroccana.* P3 biotope also has a relatively high index of specific diversity (H = 1.45), characterized by the presence of two exclusive species: *Planorbarius metidjensis* and *Anisus spirorbis.* The diversity index is low in the spring feeding the pond (H = 0.82), where only three species were sampled: *Physa acuta, Ancylus fluviatilis* and *Lymnaea truncatula.*

Equitability index present generally high values P_2, P_3 and P_4 habitats (0.80). We deduce from these results that the structure of the freshwater molluscs is well balanced in the different habitats of the pond.

3.3. Relative abundance and frequency (Fig. 2)

The distribution of species listed in different habitats of the permanent pond revealed three fundamental species (*Physa acuta, Lymnaea peregra* and *Pisidium casertanum*), two constant species (*Ancylus fluviatilis* and *Anisus spirorbis*) and four companion species (*Lymnaea truncatula, Succinea debilis, Planorbarius metidjensis* and *Lymnaea maroccana).*

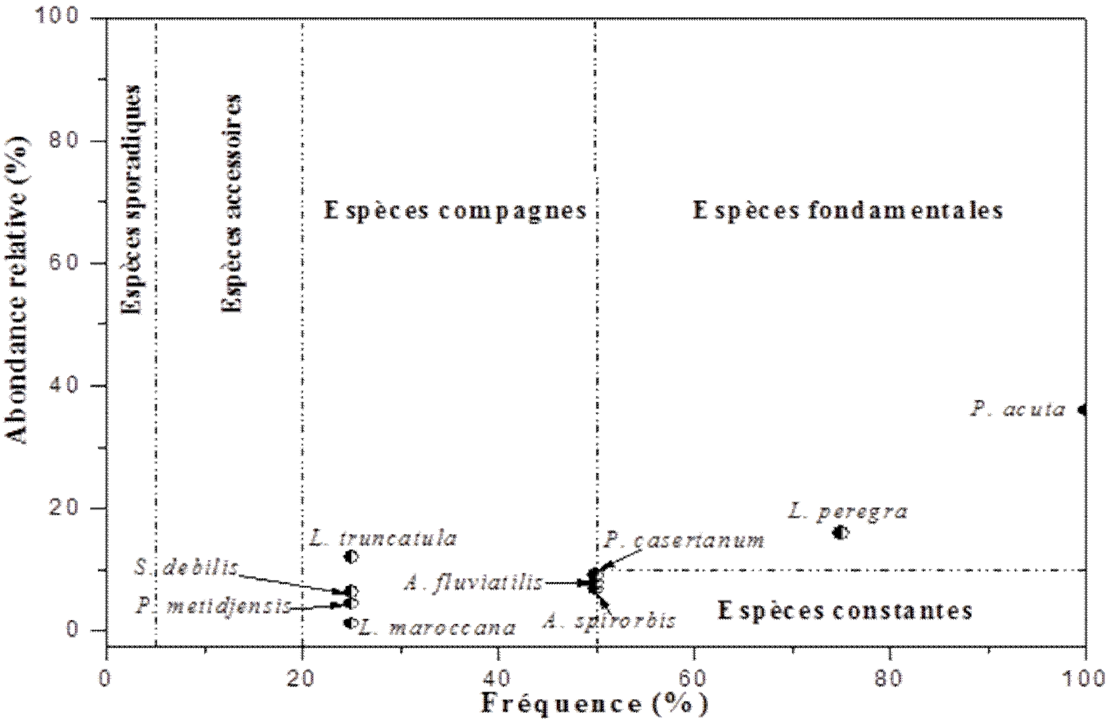

Fig 2: Position of species in habitats of dam lakes, according to their frequency relative abundances according to the classification of Vala (1985)

3.4. Ecological preferences

Populations of *Physa acuta* are well represented in the pond (Di = 0.19). They occupy all vegetation strata in the center of the area, from submerged vegetation in the riparian consisting of grasses. So, the species seems to be indifferent to the vegetation layers or type of substrate. *Lymnaea peregra* is a generalist species (Di = 0.23), but cannot develop its niche in the spring of the pond where the soil is rocky and the aquatic vegetation is lacking. *Pisidium casertanum* (Di = 0.38) and *Anisus spirorbis* (Di = 0.37) are two species collected in muddy and silty substrates. Indeed, *Pisidium casertanum* is very demanding for these types of substrate, in relation with its lifestyle, while *Anisus spirorbis* seems to prefer habitats with a dense aquatic vegetation. Furthermore, *Lymnaea truncatula* (Di = 0.73) and *Succinea debilis* (Di = 0.59) are related for riparian zone of the pond, in relation to their amphibious lifestyle.

3.5. Niche overlap indice (Table 2)

Ecological niches recovery between the two species potentially competing *Physa acuta* and *Lymnaea peregra* is very high (O = 0.96). Furthermore, the degree of overlap between other species is mainly due to lifestyle of different species; it cannot be allocated in any way to a specific competition for space or for food resources.

Table 2: Overlapping niches between freshwater snails in the permanent pool of Annasser

	L. mar.	*P. cas.*	*S. debi.*	*A. fluviat.*	*A. spiror.*	*P. Metid.*	*P. acut.*	*L. peregr.*	*L. truncatu.*
L. truncatula	0	0,31	1	0	0,27	0	0,20	0,43	1
L. peregra	0	1	0,43	0,06	0,96	0,87	0,43	1	
P. acuta	0,02	1	0,2	0,05	0,40	0,36	1		
P. metidjeis	0	0,94	0	0	0,97	1			
A. spirorbis	0	0,65	0,27	0	1				
A. fluviatilis	0,96	0	0	1					
S. debilis	0	0,31	1						
P. casertanu.	0	1							
L. marocca.	1								

3.6. Habitat Affinity (Table 3)
The faunal affinity between habitats are generally low and not exceeding 50% similarity. Therefore, the physical structure of the pond has a significant influence on the diversity and composition of the malacological population.

Table 3: Biocenotic affinities (in %) between the four biotope the permanent pool of Annasser

	P_4	P_3	P_2	P_1
P_1	12,50	14,28	50	100
P_2	28,75	33,33	100	
P_3	57,14	100		
P_4	100			

4. Discussion
The pond of Annasser has a heterogeneity of two types of habitat: quiet areas rich in aquatic vegetation and organic matter in the riparian banks and, on the other hand, a sector with agitated habitats, poor in aquatic vegetation and organic matter of the sediment. Both of them have a particular specific richness.

Most of freshwater snails harvested in this stagnant water are confined to the coastal zone, while *Physa acuta,* species the most characteristic of the facies studied, was the only species that can colonize the deep areas inside the pond. Ghamizi and Ramdani [11, 12] indicated that this species is common in Morocco and can colonize all continental water bodies. This species has shown a clear indifference the abiotic environmental conditions for recolonization and development of its ecological niche in diverse habitats. The ability is related to the reproductive system that is preferentially self-fertilizing [13, 14]. The insurance reproduction hypothesis seems to confer the status of invasive species for *Physa acuta* [15, 16].

The habitats near of the spring that feed the pond are characterized by a specific richness that differentiate them from other sites. They are marked by the presence of *Lymnaea maroccana* as an exclusive species of the pond in the Ouergha basin. The exclusive presence of the species can be explained by the fact that the pool is partially fed by groundwater related to the Annasser lake. Indeed, the water in those facies shows a high mineralization of and low variations of seasonal temperature. We can therefore consider *Lymnaea maroccana* as a typical taxa of water bodies fed by groundwater.

Ancylus fluviatilis is also characteristic of the group of species sampled in habitats with rocky and gravelly substrates (P_1 and P_2). *Lymnaea peregra, Physa acuta, Planorbarius metidjensis, Anisus spirorbis* and *Pisidium casertanum* form a group of species characteristic of habitats P3 and P_4 known by a muddy and silty substrate and an abundant aquatic vegetation dominated by *Typha angustifolia.* This species assemblage, which *Planorbarius metidjensis* and *Anisus spirorbis* are exclusive, is generally characteristic of the stagnant body waters enriched with organic matter [17, 18]. However, the presence of *Anisus spirorbis* in habitats P_3 and P_4 shows that these sites are subject of drying up of short duration. This species characteristic of permanent stagnant water can also be found in the temporary biotops where it is maintained during the dry season in sediments [19]. It could be explained by an index of a trend of these two habitats (P_3 and P_4) to move towards semi-aquatic stages, favored by increased water pumping for agricultural irrigation trend. It should be noted that the local presence of *Lymnaea truncatula* and *Succinea debilis* in the P_4 habitat cannot be correlated to the nature of the substrate, both are semi-terrestrial species commonly found in the environment in the process of eutrophication, but also along the banks of water bodies.

Finally, freshwater molluscs in Annasser ponds are closely associated with aquatic vegetation that represent for fauna a substrate, a source of food and a shelter. They are also sensitive to the physical structure the substart. In this sense, several studies have shown that the specific diversity of aquatic snails is positively correlated with the heterogeneity and complexity of natural vegetation and type of substrate [20, 21, 22].

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