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Biodiversity and seasonal dynamics of the cladoceran community in the wetlands of the Gharb and Loukkos plains in Morocco

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Abstract

The aim of this study was to describe the composition and structure of cladocerans of littoral areas with and without macrophytes from the wetlands in the Gharb and Loukkos plains (Morocco). Samples were taken between September 2004 and August 2005. The sampling of cladocerans and environmental variables was performed at four fixed points, using plankton net. Twenty-four (24) cladoceran species were recorded among the 50 species recorded in all Moroccan stagnant water. The most important species richness was observed in the permanent facies sites with 22 species, while the lowest species richness was observed in the temporary facies sites with 8 species. The average species richness was observed in the of semi- permanent facies sites with 11 species. The short duration of submersion in aquatic environments causes the seasonal extinction of species that do not develop adaptive strategies, which affects species richness of aquatic fauna in temporary habitats. Quantitative seasonal fluctuation in densities of cladocerans in the typological facies is marked by an important development since winter into summer. The lowest abundances were recorded during the winter. This limited development is due to low temperatures, which causes a slowdown in growth and spawning, and the scarcity of resources assimilated by phytoplankton cladocerans during the winter season. These results suggest that rainfall and temperature exert greater control on the dynamics of cladocerans in the studied ponds, and demonstrate the importance of these ecosystems to biodiversity in the humid region.

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Introduction

The knowledge of the fauna of limnic cladocerans in Morocco is still limited, so it is important to carry out studies on the diversity of these organisms in the different types of water bodies to increase knowledge of this key-community to the dynamics of freshwater ecosystems. The large number of ponds in Gharb and Loukkos region, coupled with the high potential of these ecosystems to store rich biodiversity that is still unknown by science, means that expansion of knowledge about its biota is imminent. Studies on these ecosystems are important for understanding and protecting these variable habitats. Thus, the present study aimed to describe the composition and diversity of cladocerans in the wtlands of Gharb and Loukkos plains.

Across the country, the labor of Ramdani (1986) have allowed a wide review of the specific diversity of crustaceans cladocerans in stagnant aquatic environments. Therefore, 50 species were identified by this author all over the country. Other studies have focused only on the dam reservoirs (Tifnouti, 1993; Fahde, 1994 Jabari, 1998; Cherifi, 2001). However, most species of cladocerans have ecological preferences for temporary or semi-permanent aquatic environment, low to medium depth, eutrophic, rich in aquatic vegetation and low pressure of predation. The majority of these conditions are not existing in the dam reservoirs, which explains the low species richness of cladocerans crustaceans often sampled in the artificial water bodies. In this sense, Jabari (1998) has reported only four species of cladocerans in the dam reservoir of Allal El Fassi (Morocco).

The choice of aquatic stagnant of the Gharb and Loukouss plains was motivated by several reasons. First of all, this area offers a wide variety of natural aquatic environments (Lakes, ponds and swamps) and artificial (rice field) which have the particularity to be affected by varying degrees of pollution. On the other hand, Cladoceran crustaceans are well represented in these wetlands and occupies an important position at the zooplankton population and aquatic biocoenosis.

We proceed in this work a qualitative descriptive study of this population in different habitats surveyed classified into three facies sites: permanent facies, semi- permanent facies and temporary facies. We also report a complete inventory of cladocerans species sampled, allowing filling gaps in the field of zooplankton inventories in natural aquatic environments. The semi -quantitative seasonal pattern densities by facies cluster was also reported in this work.

Materials and methods

Study area

Gharb plain

Gharb, also called Rharb, is a coastal lowland plain of northwestern Morocco (Figure 1). It is situated between the meridians 3°50′ and 6°35′ West and parallel 33°05′ and 35°10′. Crossed from east to west by the Sebou River, the Gharb extends about 50 miles (80 km) along the Atlantic coast and reaches some 70 miles (110 km) inland. This region is characterized by a typically Mediterranean climate, with marked oceanic influences (low annual thermic amplitude and frequent dew). The total annual rainfall ranges from 400 and 600 mm, depending the region, concentrated mainly between October and April. The monthly mean low and high temperatures are ranging from 5 to 37°C, respectively, during winter and summer. The lowland, which is bordered by the Rif Mountains to the northeast, has gradually been silted up by alluvial deposits from a seasonal watercourse, leaving a surface suitable for agriculture centred on the town of Souk-el-Arba-du-Gharb. The average altitude varies between 0 m and 200 m. These features are summarized in the Fig. 1.

Loukkos plain

The study was also carried out in the Loukkos area, one of the largest wetlands located in Northern Morocco, on the Atlantic coast (Figure 2). It is situated between northwestern coordinate 35°09′47′′N, 06°09′16′′E and southeastern coordinate 34°56′55′′N, 05°59′58′′E (Figure 2). This region have the same climate characteristics as the Gharb plain because of the proximity. The landscape is composed of wetlands (coastal lagoons, swamps and rice fields), forests, and agricultural zones.

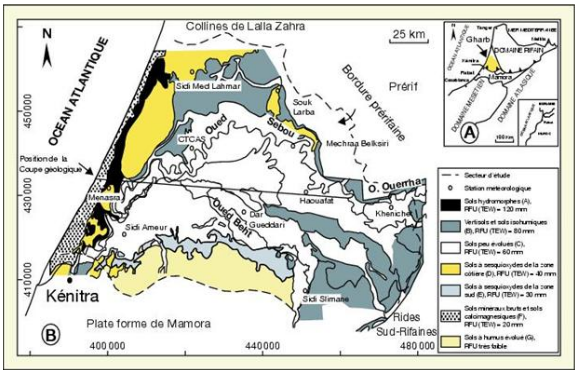

Fig. 1. Morphological card of Gharb plain.

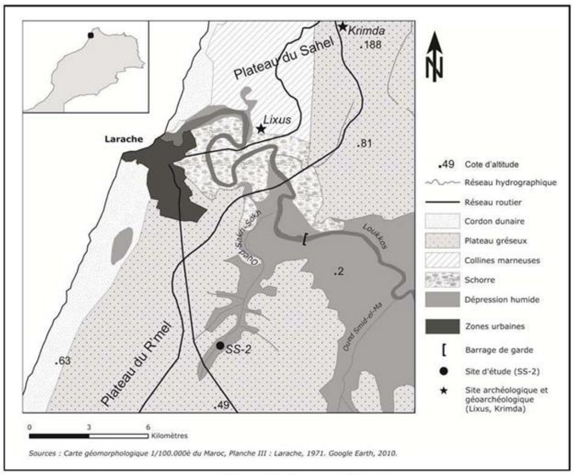

Fig. 2. Morphological card of Loukkos plain.

Twenty one (21) stations were selected at the area of study. The choice of these stations was based on species richness, abundance of taxa , aquatic vegetation, the presence of predators, the duration of flooding and the degree of pollution. The 21 stations of natural aquatic environments belong to various hydrological facies such as fresh water, temporary and permanent.

We met the stations according to the criterion of submergence duration of water. Indeed, the temporary stations which submersion is usually less than 8 months are S1, S2 and S8 belong to the Sidi Boughaba Merja (Gharb plain); S9, S10 and S11 to the Fouarate Merja (Gharb plain); S16 to the Baggara Merja (Loukkous plain). Semi- permanent wetland which duration of water submergence is between 8 and 11 months are S6 and S7 (Sidi Boughaba Merja), S12 (Fouarate Merja), S19 and S21 (Baggara Merja). Finally stations with permanent of submergence are S3, S4 and S5 (Boughaba Merja); S13, S14 and S15 (Fouarate Merja); S17, S18 and S20 (Baggara Merja).

Procedures for sampling and analysis of biological material

The cladoceran samples were taken in the fourth seasons 2004-2005 between September 2004 and August 2005, in four fixed sampling points in the littoral area of the pond, three with and one without the presence of macrophytes. Due to logistical problems, the sampling in January 2005 was only qualitative in Sidi Boughaba permanent sites.

We used the net plankton for qualitative and semi-quantitative sampling. The net used was 0.05 mm diameter mesh, 20 cm of opening diameter and 25 cm depth. The volume of water filtered is theoretically calculated using the formula: $V = \pi r^2.d$, where d is the slice surveyed (in meters) water and r is the radius of the net mouth. The procedure involves of dragging the net twice for 10 to 15 seconds in the different parts of each sampling point . However, this method apparently only allows sampling of cladocerans inhabiting the water between the macrophytes, making unfeasible the sampling of some individuals that were adhered to plants. Considering this fact, the number of individuals of the truly phytophilous species is, therefore, likely to be underestimated. fixed with 4% neutral formalin The samples collected were fixed in 4% neutral formalin immediately after collection results.

In the laboratory, the organisms were observed under optical microscope and stereomicroscope with identification performed from the usual dissection methods for microcrustaceans and specialized bibliography (Smirnov, 1996). For each sample, the quantification was carried out through three 2-mL replicates into Sedgwick-Rafter-type chambers, prepared specifically for this volume. The samples with a low number of organisms were counted in full.

Results

Faunal inventory

The purpose of this inventory is to enhance taxonomic knowledge of Cladoceran Crustacean zoological group in Moroccan natural wetlands. Species identification was based on the proceeding of Margaritora (1983), and Amoros (1984). Twenty-four cladoceran species were recorded, distributed among the families Sididae (1), Daphniidae (9), Bosminidae (1), Chydoridae (10) and Moinid*ae* (3).

Famille des Sididae Sars, 1865

- *Diaphanosoma brachyurum* Liévin, 1848

Famille des Daphniidae Sars, 1865

- *Daphnia pulex* Leydig, 1860
- *Daphnia longispina* O.F. Müller, 1785
- *Daphnia magna* Straus, 1820
- *Ceriodaphnia reticulata* Jurine, 1820
- *Ceriodaphnia laticaudata* P.E. Müller, 1867
- *Ceriodaphnia quadrangula* Baird, 1845
- *Simocephalus vetulus* O.F. Müller, 1776
- *Simocephalus expinosus* Koch, 1841
- *Scapholoberis aurita* Fischer, 1849

Famille des Bosminidae Baird, 1845

- *Bosmina longirostris* O.F. Müller, 1785

Famille des Chydoridae Stebbing, 1902

Sous-famille des Aloninae

- *Alona rectangula* Sars, 1862
- *Alona guttata* Sars, 1862
- *Alona costata* Sars, 1862
- *Leydigia quadrangularis* Leydig, 1860
- *Acroperus harpae* Baird, 1835
- *Graptoleberis testudinaria* Fisher, 1848

Sous-famille des Chydorinae

- *Dunhevedia crassa* King, 1853
- *Pleuroxus laevis* Sars, 1862
- *Pleuroxus aduncus* Jurine, 1820
- *Chydorus sphaericus* O.F. Müller, 1785

Famille des Moinidae Goulden, 1968

- *Moina brachiata* Jurine, 1820
- *Moina micrura* Kurz, 1874
- *Moina macrocopa* Straus, 1820

The highest species richness was recorded at Sidi Boughaba and Fouarate stations with 17 species in each wetland. 12 species were collected in S3. Exclusive species of permanent stations in Sidi Boughaba merja are *D. magna, A. costata* and *M. macrocopa*. Three exclusive species were also sampled in the permanent stations of Fouarate wetland: *L. quadrangularis, A. harpae* et *M. micrura*. Species richness at permanent stations of Baggara wetland is 12 species with one exclusive: *P. aduncus*.

Seasonal evolution of densities

Facies of permanent sites

The population of cladocerans in permanent sites is rich and diverse. It is composed of 22 species, more than 91% of species richness. The total annual effective in permanent sites is 268,82.10^3 ind/m^3 distributed as follows: 104,06.10^3 ind/m^3 in Sidi Boughaba wetlands (38.7 %), 96,25.10^3 ind/m^3 in Fouarate wetlands (35.8 % of total) and 68,51.10^3 ind/m^3 in Baggara wetlands (25.48 % of total) .

Seasonal evolution of the total abundance (Fig. 3) is marked by a steady increase in densities from winter to summer, followed by a slight decrease during the autumn . The peak densities reached in summer is 107,92.10^3 ind/m^3 (ie 40.14 % of the total annual density), while the minimum density reached during the winter season is 18,86.10^3 ind/m^3, (ie 7.01% of the total annual density).

The analysis of seasonal evolution in abundance of cladocerans at each ecosystem studied shows that changes are made in the same way in the three ecosystems: gradual increase in density from winter to summer and slight decrease during the fall. It should be noted that the densities recorded at the merja Sidi Boughaba are most important.

Facies of semi- permanent sites

The total annual population density of cladocerans in all semi- permanent stations is 57,46.10^3 ind/m^3

distributed as follows: 12,37.10³ ind/m³ in Sidi Boughaba wetlands sites, 27,35.10³ ind/m³ in Fouarate wetlands sites and 17,74.10³ ind/m³ at stations of Baggara.

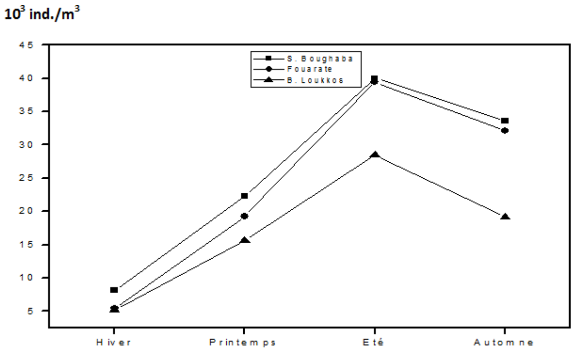

Fig. 3. Seasonal fluctuations in densities of crustaceans cladocerans in permanent facies sites.

Seasonal changes in total abundance (Table 4) has the same evolution as permanent stations : progressive augmentation of densities from winter to summer, followed by a decrease in in autumn. The minimum and maximum densities are respectively 8,11.10³ ind/m³ registered in winter and 21,38.10³ ind/m³ recorded in summer. Densities recorded at the Fouarate wetlands are the most important and represent 70.56 % of the total abundance calculated in spring. Lowest densities are those recorded at stations of Sidi Boughaba, it vary between 1,15.10³ ind/m³ and 5,33.10³ ind/m³ calculated respectively in spring and summer seasons.

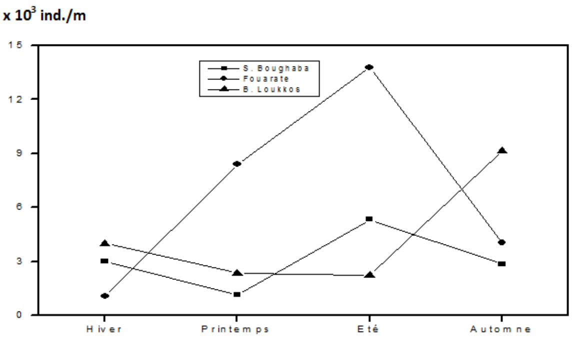

Fig. 4. Seasonal fluctuations in densities of crustaceans cladocerans in semi-permanent facies sites.

Facies temporary sites

Despite the short period of submergence, total abundance of cladocerans in the temporary stations is relatively higher compared to the semi -permanent stations. Total abundance calculated is 66,22.10³ ind/m³. Densities of *Moina brachiata* are highest in these facies sites and can reach 5,32.10³ ind/m³, abundance recorded at the station S8 in autumn.

Seasonal changes in total abundance (Fig. 5) shows a slight increase between winter and spring. Two months after early submergence in autumn, the abundance of cladocerans population is maximal with 38,78.10³ ind/m³, 60% of the total annual effective.

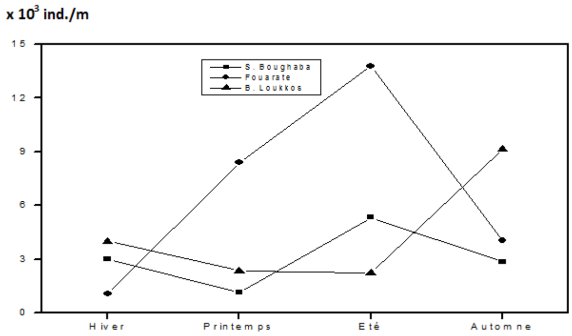

Fig. 5. Seasonal fluctuations in densities of crustaceans cladocerans in temporary facies sites.

In at each ecosystem, seasonal fluctuations follow the same evolution as the total abundance pattern. Temporary stations of Sidi Boughaba exhibit the greatest seasonal densities from 55.13 to 78.11% respectively in autumn and spring. In contrast, the densities recorded at stations of Baggara are the lowest. They represent only 6.39% to 10.41% of the total respectively during winter and autumn.

Discussion and conclusion

The results indicate that although the ecosystem studied here displays intense variations in temperature, water depth and rainfall during the annual cycle and is fed only on rainwater, this permanent, semi-permanent and temporary pond in the Gharb and Loukkos plains houses a rich biodiversity of cladocerans, mainly the non-planktonic ones, and high seasonal variation in the density and structure of their populations, which reinforces the importance of their preservation.

Components of the cladocerans biocenosis in the Gharb and Loukkos plains reveals a banal classic taxonomic composition of aquatic stagnant environments. In fact, 21 species of cladocerans were sampled in areas surveyed while Ramdani (1986) identified 50 species in all Moroccan stagnant water. The most important species richness was observed in the permanent facies with 22 species, the lowest richness was observed in the temporary facies with only 8 species. The variation in species richness in stagnant aquatic ecosystems depends both on the size of aquatic environments (March and Bass, 1995; Spencer *et al.,* 1999; Aranguren-Riaño, 2011) and duration of submersion period (Spencer *et al.,* 1999; Therriault and Kolasa, 2001; Eitam *et al.,* 2004). Aquatic environments with large area are more likely to be colonized by micro and macro crustaceans community (Wilcox, 2001; Kiflani *et al.,* 2003). Indeed, the colonization of these large freshwater habitats is favored by the diversity of microhabitats (March and Bass, 1995). In addition, the fauna is subjected to small amplitudes of temperature fluctuations (Bronmark and Hansson, 1998). The short duration of submersion in temporary aquatic environments influences most freshwater microinvertebrate who fail to complete their life cycles by the fact of drying effect. This condition causes the extinction of species that do not develop adaptive strategies, which affects species richness of aquatic fauna in temporary habitats.

In winter, the seasonal evolution of densities shows that the minimum abundances was recorded during this season. This limited development of cladocerans community is due to low temperatures causing a decline in growth and spawning. Also, the scarcity of phytoplankton resources assimilated by cladocerans during this season contributes to the abundance reduction of this zoological group. Predation by *Chaoborus* larvae is another factor responsible of reducing densities of cladocerans populations during winter season.

In spring and summer, we observed an increase in density, due to the restoration of favorable abiotic conditions like temperature, nutrition water transparency. Indeed, zooplankton is growing very rapidly with increasing of water temperature passing from 10-12°C to 26-28°C. The emergence and dominance of Daphniidae during the summer stage could be related to the fact that these types of zooplankton are herbivorous (Tifnouti, 1993; Thackeray, 2012). They also feed by grazing nutritive material overlying the substrate (Pourriot *et al.,* 1982).

During the fall season, we observed a density reduction of zooplankton in permanent and semi-permanent facies sites. It is due to water temperatures drop and food scarcity due to dominance of phytoplankton unavailable for grazing such as *Clostercum, Straurastrum* and *Synedra*. In contrast, high cladocerans species abundance are reached during autumn in the temporary facies sites. It is a kind of adaptation strategy for summer dryness whose exposure will be longer than 6 months (Aoujdad, 2007; Nevalainen, 2013).

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