The impact of interannual climatic fluctuations on the species composition and the dynamics of plant communities in Mediterranean temporary pools (western Morocco)

Rhazi Laïla[1], Grillas Patrick[2], Rhazi Mouhssine[3] & Aznar Jean-Christophe[4]

1. University Hassan II Aïn Chock, Faculty of Sciences, Aquatic Ecology and Environment Laboratory, BP 5366 Maarif Casablanca, Morocco
2. Tour du Valat, A research center for the conservation of Mediterranean wetlands, Le Sambuc, 13200 Arles, France;
3. University of Aix-Marseille III, Faculty of Sciences and Techniques, Saint Jérôme, 13397 Marseille Cedex 20, France
4. Direction of Forest Research, Forest Quebec, 2700, Einstein, Saint-Foy, Quebec, Canada G1P 3W8

Introduction

In Morocco, temporary pools are numerous and constitute very important sites for biodiversity (Grillas et al, 2004). There are submitted to very strong anthropogenic pressures by the local populations through domestic grazing, leisure activities, etc. Previous work showed that the specific composition of the vegetation varied significantly along the topographic gradients and between years with distinct temporal patterns for the annuals and the perennials (Rhazi et al, 2001). Moreover, the composition of the vegetation varies with the land use in periphery of the pools. These results suggest that the flora of a pool is made up of 2 groups of species: Characteristic and Opportunist species. The latter find in the pool a temporarily favourable habitat during the dry phase (Rhazi et al, 2006). The objective of this work was to study the inter-annual dynamics of the vegetation (10 years) in relation to rainfall, comparing the Characteristic/ Opportunistic species as well as Annual/perennial The initial hypothesis were as follows: (1) each year, under the control of the hydrological conditions, only a fraction of the pool species is growing, (2) the Opportunistic species constitute a large fraction of the vegetation and its importance varies with hydrology, (3) the Characteristic species are more stable in time than the Opportunistic species.

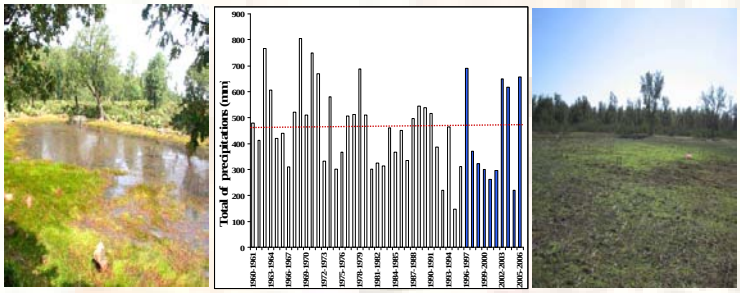

Figure 1: Total rainfall during annual hydrological cycles (September-August) between 1960 and 2006 at Benslimane (in blue years of this study; broken line: average of 1961-2006)

2. Material and methods

The studied site is a temporary pool in the Cork-oak forest of Benslimane (33°38' N, 7°07' W) located between Rabat and Casablanca. This region is submitted to a semi-arid Mediterranean climate, with a mean annual rainfall (1961-2006) of 450 mm and large inter-annual fluctuations (range: 142,2 - 803,7 mm,
The vegetation was studied from 1997 to 2006 with two visites/year (March-April and June) on quadrats (79 quadrats 0,3 X 0,3 m divided into 9 squares) distributed every 2m along two transects orthogonal permanent passing by the deepest part of the pool. The abundance of each species per quadrat was measured as the number of squares in which it was found (0 to 9). The water level was measured at each quadrats. Two groups of species were distinguished (1) the Characteristics: aquatics and amphibious species (*sensu lato*), identified as characteristics of Mediterranean temporary pools by Nègre, (1956) and Médail et al, (1998) and (2) the Opportunistics: terrestrial species not characteristic of the pools. The annual or perennial trait was attributed following the flora of North Africa (Maire, 1952-1987) and Morocco (Fennane and al, 1999, 2007). The total richness, the richness in annuals, in perennials, in Characteristics and Opportunistic species was calculated for each year. A correspondence analysis (CA) was performed on the 10 years data of vegetation taking for each species and each year the maximum value of abundance observed by quadrat (two visits per year). The CA was carried out with 78 species while excluding those met less than four times during ten years. The barycentres of the distribution of the quadrats of each year were positioned on the ½ biplot. Variations in time of the total specific richness, measured as the total number of species listed per year on the whole of the quadrats, and for its components ("Characteristics"/"Opportunistics", "Annual"/ "Perennial") were studied by nonparametric correlations of Spearman. The difference in frequencies for each species between dry and wet years was tested by nonparametric variance analysis (Kruskall-Wallis).

3. Results

During the 10 years, the rainfall fluctuated widely between wet and dry years (Fig. 1), resulting in large differences in the annual maximum water level recorded (40-54 cm in wet years, 5-17 cm in dry years) and in the duration of flooding duration (3-23 weeks).

3.1. Temporal dynamics of the vegetation

Axis 1 (32% of variance) of the CA (Fig. 2), opposes the terrestrial species (*Sanguisorba minor, Cistus salviifolius, Lolium rigidum*...) to the aquatics (*Myriophyllum alterniflorum, Callitriche brutia, Ranunculus peltatus*....). Axis 2 (26% of total inertia) opposes the forest terrestrial species (*Gaudinia fragilis, Stachys arvensis, Anagallis arvensis*...) to the characteristic amphibian pool species (*Pilularia minuta, Damasonium stellatum, Exaculum pusilum, Elatine brochonii*...). The annual barycentre of the quadrats shows an important displacement on the ½ biplot of CA (Fig. 2). The coordinates on axis 1 of the annual barycentres are significantly correlated with the maximum depth of water ($r^2 = 0.84$; $p < 0.001$; $n = 10$). This axis 1 opposes the wet years (1997, 2003, 2004 and 2006) to the dry years (1998, 1999, 2000, 2001, 2002 and 2005). The coordinates on axis 2 of the barycentre of the quadrats per year increase significantly with the years (Correlation of Spearman, Rho = 0.91, $p<0.001$) they are also significantly correlated with the total species richness ($r^2 = 0.68$; $p<0.01$; $n=10$).

3.2. Richness of the communities

The total number of species found each year in the pool doubled for the period of study (from 28 to 68) with a progressive increase (Fig. 3) (Rho = 0.91, $p< 0.001$). The number of Characteristic species of the pools (between 20 and 35 species per year) was significantly correlated with rainfall ($r^2 = 0.61$, $p<0.01$) but did not show a significant trend in time (Spearman Rho = 0.34, p = 0.34). On the other hand the number of Opportunistic species increased quickly (Rho = 0.66, $p<0.05$) from a very low value (3 species) in 1997 (very wet) to fluctuate between 24 and 39 species since 2001.

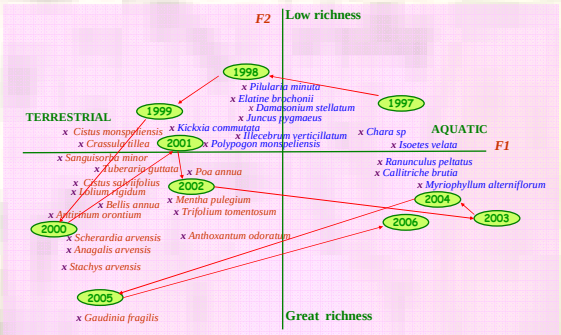

Figure 2. Plot ½ of the CA vegetation (1997-2006) with positioning of the barycentres of the years (in red terrestrial species, in blue Characteristic pool species)

The Opportunistic species contributed for about 10% of the flora in 1997 and 50% from 2003 to 2006 (Fig. 3). The numbers of perennial and annual species were near during the first year (1997). The number of perennials increased slowly (Rho = 0.88, $p <0.001$) reaching 18 species in 2006. The number of annuals increased quickly during the first years (Rho = 0.89, $p <0.001$) to stabilize between 43 and 50 species from 2003. The contribution of the annual species to the flora of the pool passed from 60 to 70%. Among the Characteristic pool species, 14 were significantly more frequent during the humid years and 2 during the dry years (*Polypogon monspeliensis* and *Hypericum tomentosum*) (Tab. 1).

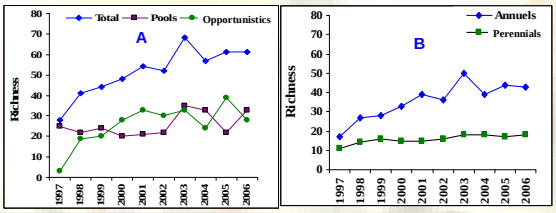

Figure 3: Inter-annual variations of the number of species; (A) Characteristic Pool species, Opportunistic and Total, (B) Perennial and annual species

	Occurrence (years)			Test		
Species	Total	Wet	Dry	Pref.	Chi²	p
Damasonium stellatum	4	4	0	Wet	8.37	**
Elatine brochonii	4	4	0	Wet	8.37	**
Pilularia minuta	4	4	0	Wet	8.3	**
Lythrum thymifolium	5	4	2	Wet	6.93	**
Lythrum hyssopifolium	8	4	4	Wet	6.75	**
Eleocharis palustris	10	4	6	Wet	6.62	**
Heliotropium supinum	9	4	5	Wet	6.62	**
Scirpus pseudocetaceus	3	3	0	Wet	5.62	*
Juncus capitatus	3	3	0	Wet	5.62	*
Lythrum borysthenicum	6	4	2	Wet	5.36	*
Exaculum pusillum	6	4	2	Wet	4.39	*
Cerastium glomeratum	4	3	1	Wet	4.3	*
Mentha pulegium	8	4	4	Wet	3.79	*
Isoetes velata	10	4	6	Wet	4.12	*
Spergula arvense	9	3	6	Dry	5.36	*
Polypogon monspeliensis	9	3	6	Dry	4.15	*
Scilla autumnalis	9	3	6	Dry	5.07	*
Hypericum tomentosum	10	4	6	Dry	4.6	*
Anthirinum orontium	4	0	4	Dry	3.8	(*)

Table 1: Results of the tests for significant differences in the occurrence of species between wet (4) and dry years (6); for each species are given the number of years the species was present (Total) during the 10 years (Tot), during the 4 wet years (Wet) and the 6 years dry (Dry), the preference for dry or wet years, the value of Chi² (Kruskall-Wallis) and the probability (* = p< 0.05, **= p< 0.01).

4. Discussion

The temporary pools constitute habitats particularly sensitive to environmental changes, in particular those affecting their hydrological dynamics (Rhazi et al, 2001). The period of study was characterized by an alternation of contrasted dry and wet years. The first year was very wet with the maximum water levels reached in the pool. The vegetation is representative of the oligotrophic Mediterranean temporary pools of Morocco (Rhazi et al, 2001) with notably a high richness in annual species (>65% of the total). The Characteristic pool species contributed for only 39% to the total number of species found in the pool during 10 years but they were more frequent than the other species. The contribution of the Characteristic pool species was high the first year (90%) and fluctuated then between 50 and 36% after 2003.
The species composition of the vegetation of the pool was not stable during the 10 years of study and showed 2 distinct patterns (½ biplot of the CA): (1) during the first years (1997-2002) a directional dynamics (succession) accompanied by an increase of the species richness and (2) an alternation between dry and wet years with inter-annual changes in the species composition. During the first year, exceptionally wet, the vegetation was almost exclusively made up of Characteristic pool species. These Characteristic pool species did not show a significant trend over time. The following years, the Opportunistic (terrestrial) species increased significantly until 2003 when it stabilized with large inter-annual variance (Fig. 2). Both the Perennials and the Annuals increased significantly over his period, but the increase was stronger for the Annuals. On such a short period (10 years), the trends observed seem to result from a recover of the vegetation after one year exceptionally wet (1997) which could be considered as a disturbance that eliminated from the pool the majority of the terrestrial species and in particular the perennials. No negative interaction between groups of species could be found suggesting that the competition is not a dominating factor in the richness of these communities. The intensity of the stresses related to the climatic fluctuations seems to be the main factor controlling the specific richness of the vegetation.