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Functional traits of six amphibious plants along a latitudinal gradient in Moroccan temporary ponds

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Introduction

Mediterranean temporary ponds show alternating phases of drought and flooding, corresponding to the characteristic Mediterranean climate. This alternation is coupled with a moisture gradient that behaves as a selective filter on plants at local scale. Precipitation-dependent water levels and moisture gradients determine the selection of functional traits of plants at the global to local scale. In the Moroccan Atlantic plains, temporary ponds are found under different climatic conditions along the latitudinal gradient (N-S) with a decrease of precipitation (resulting in a shorter hydroperiod) from North to South. Along this gradient, temporary pond species are found in diverse hydrological and soil conditions.
The aim of this work was to test (1) if functional traits of species differ along a latitudinal and climatic gradient and (2) if differences result from plastic response or local adaptation.






Materials and methods

Three vegetative (height, number of leaves, leaf area) and one reproductive (seed weight) life-history trait(s) of six amphibious plant species (*Baldellia ranunculoides*, *Damasonium polyspermum*, *D. bourgaei*, *Elatine brochonii*, *Isoetes setacea* and *I. velata*), were studied in 20 ponds distributed along a north-south gradient (35°-31°N; spanning about 750 km) in Morocco (Fig. 1). The selected ponds are located in six regions distributed along a climatic gradient (precipitation ranging between 1060 and 217 mm annually) (Fig. 1). In each pond, traits were measured on 11 individuals/species/pond collected in the field. The same traits were also measured on individuals (10/species/pond) from the same populations but cultivated from seeds/corms (collected during summer after the end of the life cycle) under controlled laboratory conditions.

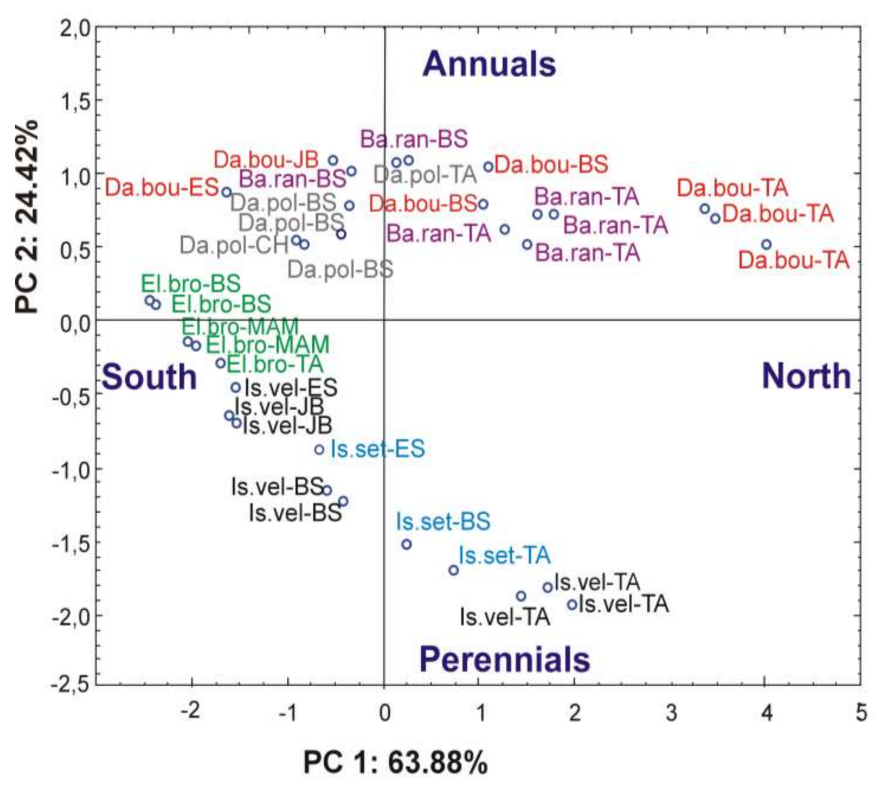

Fig. 2A: PCA of the measured traits on individuals collected in the **field** of six species (*Ba.run: Baldellia ranunculoides; Da.bou: Damasonium bourgaei; Da.pol: D. polyspermum; El.bro: Elatine brochonii; Is.set: Isoetes setacea; Is.vel: I. velata*) from 20 ponds of six regions distributed along the North-South gradient

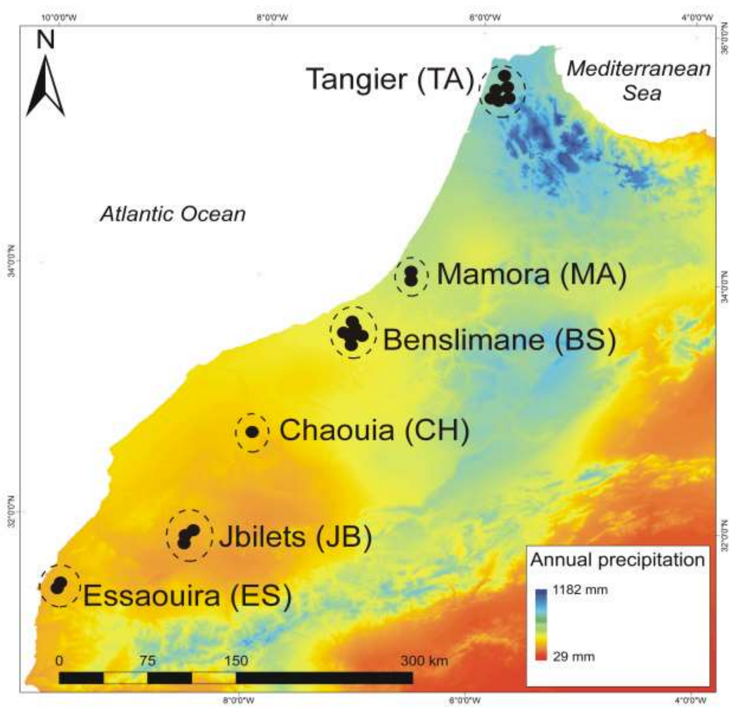

Fig. 1: Location of the 20 temporary ponds used to collect the six amphibious species in this study

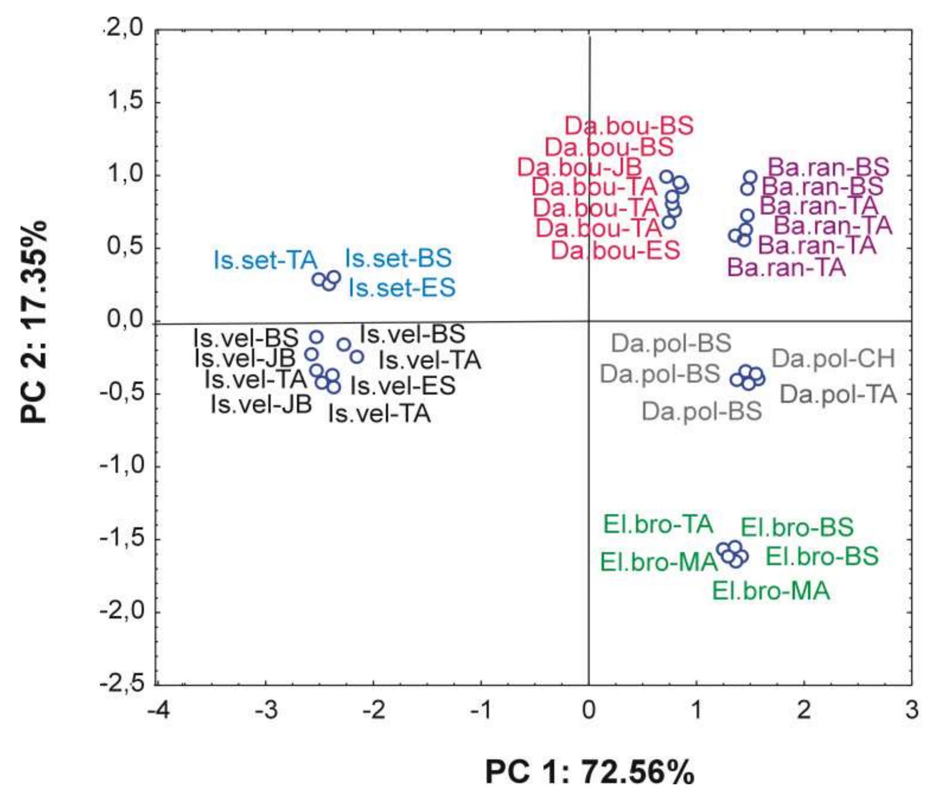

Fig. 2B: PCA of the measured traits on individuals grown in the **laboratory** of six species (*Ba.run: Baldellia ranunculoides; Da.bou: Damasonium bourgaei; Da.pol: D. polyspermum; El.bro: Elatine brochonii; Is.set: Isoetes setacea; Is.vel: I. velata*) from 20 ponds of six regions distributed along the North-South gradient

Results and discussion

Latitude was significantly correlated with precipitation (r^2= 0.75; p<0.0001). Field collected plants showed a significant correlation between latitude and plant functional traits (Table 1A). The populations of each species well separated along the latitude gradient which explained about 64% of the total variance (Fig. 2A). From North (Tangier) to South (Essaouira), the individuals for all species became shorter, with smaller and fewer leaves and lighter seeds (Fig. 3). These differences were related to a drier climate (Table 1B) resulting in shorter hydroperiods which constitute a stress for plants, limiting their development. However, this variation in plant traits was no longer expressed when plants were cultivated under homogeneous ('common garden') conditions (Table 1A); the species showed similar functional traits between regions (Fig. 4) and the populations for each species remained aggregated along the latitude gradient (Fig. 2B).

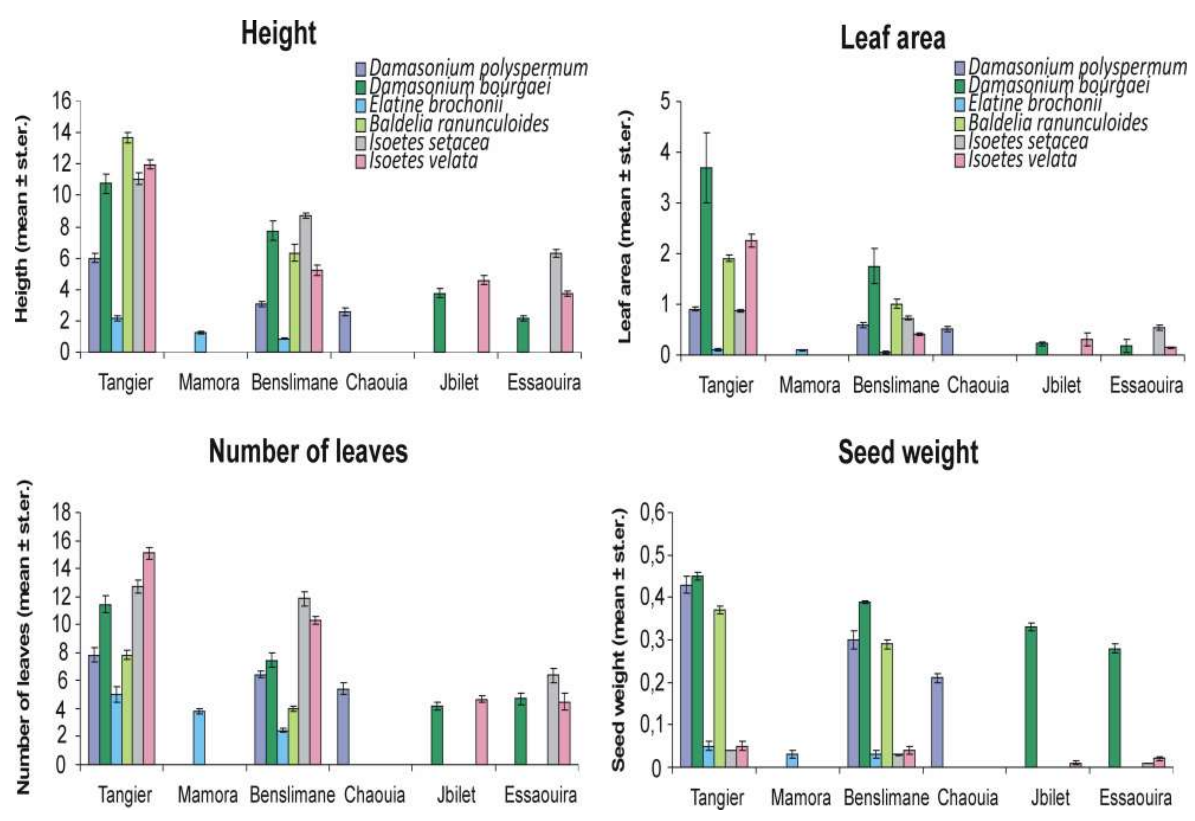

Fig. 3: Variation between regions (from the north: Tangier to the south: Essaouira) in traits measured in the field for the six studied species.

Table 1. Spearman Rank correlations (A) between latitude and plant traits measured on individuals collected in the field and on individuals grown in the laboratory and (B) between traits on individuals collected in the field and precipitation.

Traits	A- Latitude				B- Precipitation	
	Field		Culture		Field	
	Rho	*P*	*Rho*	*p*	*Rho*	*P*
Height	0.56	**	-0.08	ns	0.49	**
Number of leaves	0.56	*	-0.26	ns	0.47	**
Leaf area	0.59	***	-0.23	ns	0.51	**
Seed weight	0.54	**	0.21	ns	0.37	*

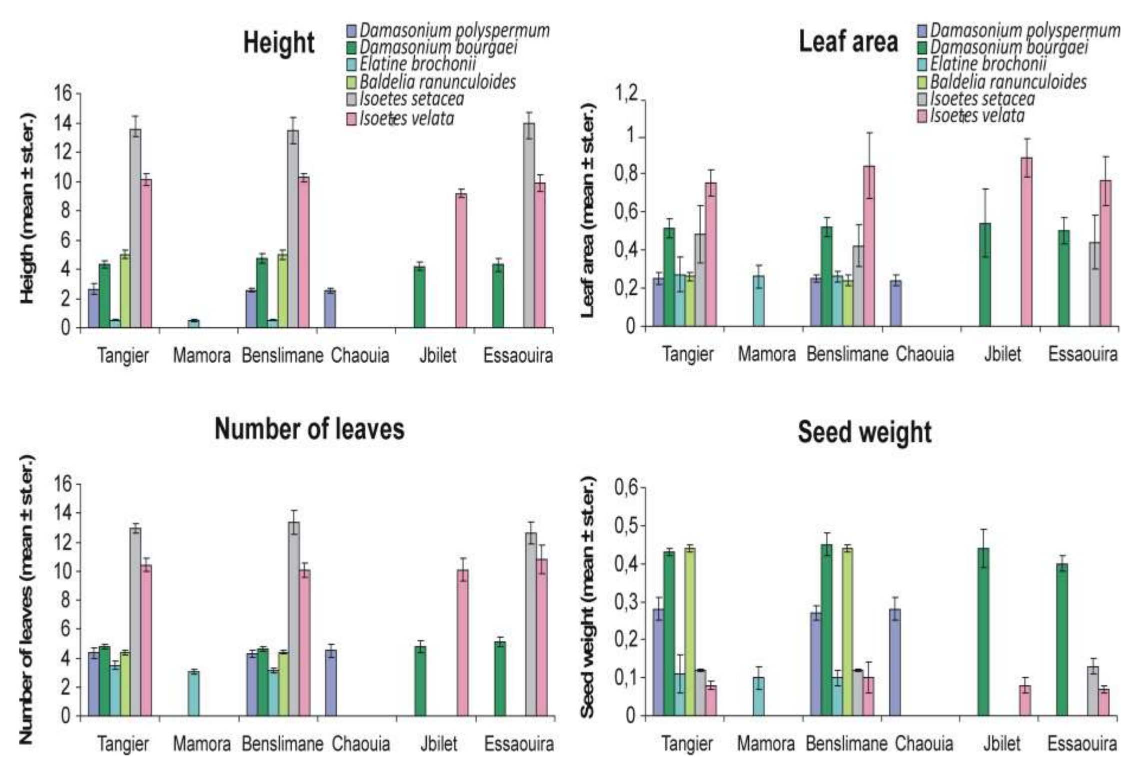

Fig. 4: Variation between regions (from the north: Tangier to the south: Essaouira) in traits measured in culture for the six studied species.

CONCLUSIONS

Our findings suggest that the differences revealed in functional traits of the six studied plants result from plastic response of the plants rather than from genetic adaptation to local environmental conditions. This plasticity of the species contribute to their resilience to environmental fluctuation and climate change and could facilitate eventual population transfer in restoration projects.