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Changes in foliar traits through environmental gradients in two Mediterranean *Quercus* species and their hybrids

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Introduction

Although hybridization could be relevant for the persistence of populations in a changing climate [1], the truth is that its long-term effects are unpredictable and require case-by-case studies. In this work, we analyze different morphological leaf traits in two species (*Q. faginea* and *Q. pyrenaica*) and their hybrids, across environmental gradients, to try to determine if there are traits that could confer an advantage to any of the groups under the new climate provided. We propose that hybrids must have some trait that confers lower fitness, allowing the persistence of the parents [2], and that foliar traits must respond at intraspecific level to climatic changes between areas [3].

Material and methods

Table 1. List of examined characters, notation and units.

Leaf thickness	LT	mm
Leaf mass per unit area	LMA	gm^{-2}
Leaf area	LA	cm^2
Leaf perimeter	PM	cm
Leaf lamina length	LL	cm
Length of petiole	LP	cm
Total leaf length (LL+LP)	TLL	cm
Maximal width of lamina	MWL	cm
Length of lamina from base to widest part	LLW	cm
Distance from the main vein to the apex of the greater lobe	DA	cm
Distance from the main vein to the sinus below the greater lobe	DS	cm
Number of lobes	NLT	nº

The study was carried out in three areas (warm zone, intermediate and cold zone) located in the Central-West of Spain. In each area, three plots and 10 specimens in each plot (genetically categorized using AFLPs) were selected corresponding in one case to *Q. faginea*, in another to *Q. pyrenaica* and in another plot to the hybrid category. From each individual, leaf samples were taken and used for morphological analysis (Table 1). Differences between genetic groups and sites across the gradient were analyzed by SPSS ver. 23.0.

Results and discussion

Table 2. Mean value (n = 10, standard error in parentheses) obtained for each leaf trait in each genetic group in the three zones of study. Different letters for each trait indicate significan differences between genetic groups in each area. Notation and units as in Tab 1.

Warm zone	**LMA**	**LA**	**PM**	**LL**	**LP**	**TLL**	**MWL**	**LLW**	**DA**
Q. faginea	122 (1.81) a	11.3 (1.16) b	19.5 (1.27) b	5.45 (0.28) b	0.88 (0.07) b	6.23 (0.32) b	2.63 (0.13) c	2.62 (0.12) b	1.35 (0.06) c
Hybrids	104 (3.41) b	13.3 (1.53) b	22.0 (1.89) b	5.72 (0.33) b	0.94 (0.06) b	6.70 (0.39) b	3.38 (0.14) b	3.05 (0.10) b	1.73 (0.09) b
Q. pyrenaica	90 (1.44) c	27.0 (2.07) a	47.0 (0.82) a	8.85 (0.39) a	1.49 (0.03) a	10.4 (0.40) a	4.83 (0.14) a	4.56 (0.23) a	2.81 (0.10) a
Intermediate zone									
Q. faginea	125 (5.00) a	8.13 (0.56) b	17.0 (0.81) b	4.49 (0.25) b	0.78 (0.05) b	5.36 (0.29) b	2.43 (0.07) c	2.27 (0.18) b	1.30 (0.03) c
Hybrids	110 (3.69) b	10.3 (1.47) b	20.3 (2.87) b	4.87 (0.48) b	0.81 (0.08) b	5.75 (0.56) b	3.11 (0.19) b	2.77 (0.35) b	1.70 (0.05) b
Q. pyrenaica	95 (1.58) c	23.3 (2.65) a	44.5 (3.29) a	7.84 (0.38) a	1.28 (0.06) a	9.09 (0.40) a	4.91 (0.16) a	4.20 (0.19) a	2.68 (0.18) a
Cold zone									
Q. faginea	126 (2.16) a	5.87 (0.67) b	15.9 (1.14) b	4.48 (0.17) b	0.70 (0.03) b	5.05 (0.18) b	1.87 (0.12) c	2.17 (0.18) b	0.98 (0.05) c
Hybrids	108 (3.29) b	9.14 (1.38) b	18.4 (1.09) b	5.20 (0.46) b	0.77 (0.02) b	5.97 (0.44) b	2.49 (0.22) b	2.77 (0.22) b	1.30 (0.09) b
Q. pyrenaica	95 (1.90) c	21.2 (1.48) a	37.1 (2.09) a	7.65 (0.23) a	1.17 (0.06) a	8.82 (0.23) a	4.35 (0.17) a	4.41 (0.19) a	2.50 (0.08) a

Only three traits (LMA, MWL, DA) revealed discriminant value between the three genetic groups, with intermediate values in the hybrids. For the rest of the traits, the hybrids showed much closer proximity to *Q. faginea* (Table 2). These differences were consistent in the different study areas, suggesting a genetic basis. The leaves of *Q. pyrenaica* show less weight per unit of surface, area and width and longer petioles (Table 2), all of which are traits that, in principle, would confer this species disadvantages in the conditions of less water availability that are assumed in the future [3, 4].

Table 3. Variability (CV, %) in the traits of the same genetic group across the 3 study areas. Notation and units as in table 1.

	LA	**PM**	**LL**	**LP**	**TLL**	**MWL**	**DA**	**DS**	**NTL**
Q. faginea	28	10	11	11	11	16	15	15	9
Hybrids	18	8	8	10	8	14	14	14	17
Q. pyrenaica	12	11	8	12	9	6	6	9	22

In all groups, leaves tend to be larger, with longer petioles and more lobes and deeper in the warmer zone (Table 2). *Q. faginea* was the group that showed, in general, greater capacity to modify its traits in response to climatic changes between zones (Table 3), which added to its foliar characteristics suggests a greater probability of success in the face of climate change [5, 6].

References

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