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GAMETOPHYTE LENGTH VARIATION AMONG ANTARCTIC POPULATIONS OF *Polytrichum juniperinum* HEDW. (POLYTRICHACEAE)

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Abstract: *Up to now, no sporophytes of Polytrichum juniperinum were recorded in Antarctica. Therefore, the long distance dispersal may be a rare event in this continent. In this study, we recorded the length of gametophytes sampled in natural populations from an Antarctic island, aiming to evaluate the presence of patterns of morphological differentiation related to short distance dispersal of vegetative propagules. The mean size of gametophytes ranged from 2.85±0.59 cm to 7.01±1.34 cm, with significant overall differentiation according to the analysis of variance. The populations' pair-wise comparison was significant in 20 out of 21 pairs. In terms of clustering of morphologically similar populations due to short distance dispersal, the degree of morphological differentiation between sample locations slightly increased with geographical distance, although not statistically significant. Considering the absence of significant correlation between gametophyte size and geographic distance observed for the populations studied, adaptation to micro-environment seems to be the best explanation for the observed differentiation. Further morphological records and studies based on molecular genetic markers are being developed by our group, in order to determine if such differences have also some genetic basis.*

Keywords: Moss, Phenotypic Plasticity, Polytrichaceae

Introduction

Polytrichum juniperinum Hedw. (*Polytrichaceae*) is a common dioecious medium-sized pioneer moss species with cosmopolitan distribution over the world. In the Antarctic continent, *P. juniperinum* is confined to maritime Antarctic, where it is a widespread moss species (Ochyra 1998), developing on ice-free areas, except in sites with excess moisture (Victoria *et al.*, 2009).

Previous field observations suggest the occurrence of variation in gametophyte size among Antarctic populations of *P. juniperinum*. Geographic variation in morphology may reflect phenotypic responses to environmental gradients and evolutionary history of populations, suggesting local or regional changes in environmental conditions. Despite the cosmopolitan occurrence of *P. juniperinum*, the Antarctic continent lacks studies dealing with morphological variation among populations of this species. Up to now, no sporophytes of *P. juniperinum* were recorded in Antarctica (Ochyra 1998; Putzke & Pereira 2001) and, therefore, the long distance dispersal may be a rare event in this continent. If morphological characteristics have a solely genetic ground, short distance dispersal of vegetative propagules may result in the establishment of clusters of morphologically similar populations. On the other hand, if morphological characteristics are effect of plasticity to micro-environments, the populations tend to lack patterns of clustering related to morphological characteristics.

In this study, we report the analysis of the length of gametophytes sampled in seven natural populations from Nelson Island, Antarctica, aiming to evaluate the presence

of patterns of morphological differentiation related to short distance dispersal of vegetative propagules.

Materials and Methods

Gametophytes of *P. juniperinum* were collected in seven populations (P27, P967, P32, P81, P63, P34 and P166) occurring in ice-free areas of the Nelson Island (Figure 1). Thirty individuals from each population were randomly selected and gametophytes length were measured using a millimetric scale (see insert in Figure 2). Pair-wise population means were compared using a two-tailed *t*-test. The correlation between morphological differentiation (Euclidean distance) and geographical distance among populations was evaluated by regressing the population pair-wise morphological differentiation matrix against the pair-wise geographical distance matrix, using a Mantel test with 1000 permutations for the determination of the statistical significance.

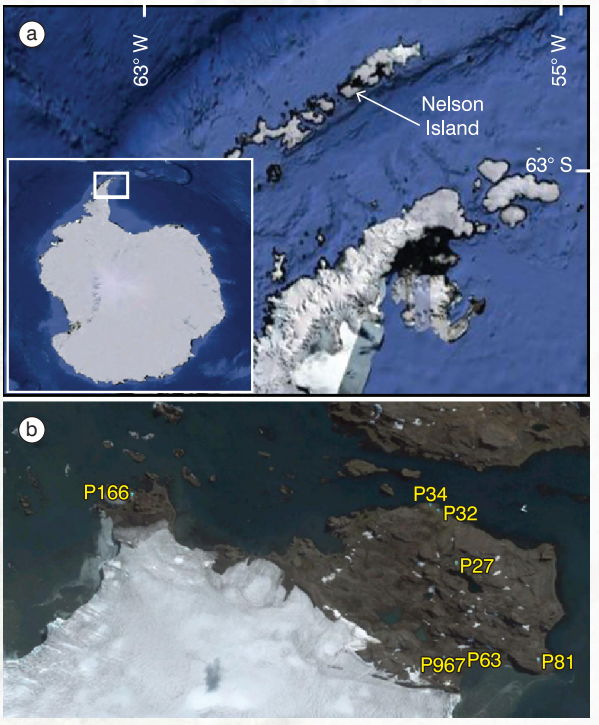

Figure 1. (A) Location of the Nelson Island in the Antarctic Continent. (B) Location of the seven studied populations (P27, P967, P32, P81, P63, P34 and P166) in Nelson Island.

Results

The mean size of gametophytes ranged from 2.85±0.59 cm to 7.01±1.34 cm (Figure 2), with significant overall differentiation (F = 70.01; p<0.0001) according to the analysis of variance (ANOVA). The populations´ pair-wise comparison was significant in 20 out of 21 pairs (Table 1).

Since the population's mean is highly influenced by extreme values in the data-set, we also recorded the mode (the most frequent value in the data) for each population. The values of the mode were similar to the means (data not shown), suggesting that the outliers do not bias the results. In terms of clustering of morphologically, similar populations due to short distance dispersal, showed through the Mantel test that the degree of morphological differentiation between sample locations slightly increased with geographical distance, although not statistically significant (r = 0.12; p = 0.72).

Discussion

At morphological level, the present study revealed significant inter-population differentiation for the gametophyte length. Excluding phenotypic plasticity, the existence of differences among populations of *P. juniperinum* may be related to three different facts: (i) newly arriving

Table 1. Populations pair-wise comparison for the gametophyte size.

	P32	P81	P63	P166	P34	P27
P967	***	***	***	***	***	***
P32		***	***	**	***	***
P81			**	***	***	n.s.
P63				***	***	**
P166					***	***
P34						***

Statistical significance assessed by Student's *t*-test. ***: $p < 0.001$; **: $p < 0.01$; n.s.: not significant.

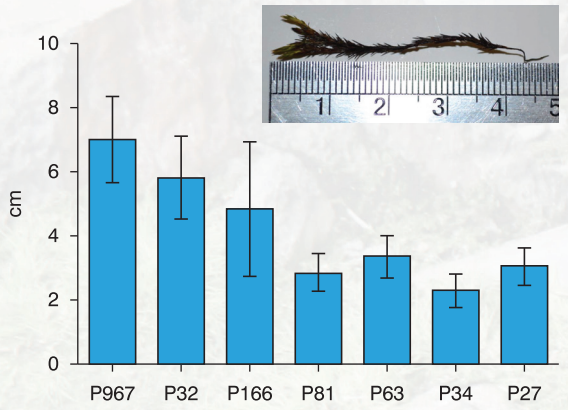

Figure 2. Means of the data recorded from gametophytes sampled in seven populations (P27, P967, P32, P81, P63, P34 and P166) in Nelson Island, Antarctica. Bars in the means are the standard deviation. Insert: Measurement of a gametophyte of *Polytrichum juniperinum* using a millimetric scale.

propagules colonizing limited areas only, (ii) a drift-like effect of random elimination of haplotypes during periods of population decline, and (iii) adaptation to the local environment (Adam *et al*., 1997).

Buryová & Shaw (2005) evaluated the size of gametophytes and leaves of the moss *Philonotis fontana* in a garden experiment aiming to study the phenotypic plasticity of the species. These authors reported absence of significant difference in length of the gametophytes, whereas size of the leaves expressed statistically significant difference among populations. They suggested the existence of genetic differences among populations and significant effects of light intensity detected in stem diameter, nerve and cell width, whilst water levels in the experiment had a noticeable effect just on leaf length.

Even considering the significant differentiation of gametophyte size among populations, the absence of significant correlation between this morphological characteristic and geographic distance observed for the studied populations of *P. juniperinum* suggests that adaptation to micro-environment is the best explanation for this differentiation. However, garden experiments and genetic analysis are required to test this hypothesis.

Conclusion

The overall and pair-wise significant difference among populations of *P. juniperinum* based on gametophyte length revealed in this study suggests the presence of plasticity related to micro-environmental conditions, although genetic differentiation cannot be discarded. Further morphological records and studies based on molecular genetic markers are being developed by our group, in order to determine if such differences have a genetic ground.

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