Ecology and Ecophysiology of Subantarctic Campbell Island Megaherbs

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Abstract

The megaherb growth form is not common in the New Zealand flora; yet it is a distinctive feature of the flora of New Zealand's subantarctic islands, such as Campbell Island (52°33'S, 169°09'E). It occurs in four genera: *Pleurophyllum, Stilbocarpa, Bulbinella* and *Anisotome*. Their unusually large form and striking colourful flowers have long been commented as possible relics of a more widespread flora or possibly more recently dispersed and adapted to the present conditions. This research focussed on how well they are adapted to their environment and how adaptable they may be to novel conditions using ecophysiological methods. The breeding system of *Pleurophyllum* was also looked at as an example of the development of reproductive systems in an isolated island environment.

Biomass allocation patterns were investigated in two species, *A. latifolia* and *P. speciosum* in order to determine whether this growth form was extraordinary compared with other herbaceous perennials. Six shoots of each species were harvested on the island, and sorted into components (leaf, stem, rhizome, reproductive) and dried back on the mainland. Leaf:stem ratios were found to be higher in both species than other perennials. This may be a response to ensure adequate resource harvesting i.e. light, water, nutrients, in an exposed, competitive environment.

Gas exchange was studied in different light and temperature regimes using a growth cabinet in order to determine light and temperature tolerance and possible optima. Nine plants each of subantarctic *Pleurophyllum criniferum*, *Anisotome latifolia*, *Stilbocarpa polaris* (three plants only), New Zealand subalpine *Ranunculus lyallii*, and Chatham Island *Myosotidium hortensia* were exposed to three temperatures (7°C, 17°C, 25°C) and four light levels (0, 150, 380 and 950 $\mu mol\ m^{-2}\ s^{-1}$). *P. criniferum* had the fastest photosynthetic rate (of 8.6 $\mu mol\ m^{-2}\ s^{-1}$), followed by *R. lyallii* (7.8 $\mu mol\ m^{-2}\ s^{-1}$), *A. latifolia* and *M. hortensia* (both with 4.6 $\mu mol\ m^{-2}\ s^{-1}$) and *S. polaris* (2.1 $\mu mol\ m^{-2}\ s^{-1}$) (averaged over all light and temperature levels). All species had higher photosynthetic rates at the highest light level. *P. criniferum* did not appear to be inhibited by the high temperatures while *A. latifolia* did. Respiration rates increased with temperature with *A. latifolia* having the highest rate followed by *M. hortensia, P. criniferum, R. lyallii* and *S. polaris*. These results

suggest that although the subantarctic megaherbs appear to be well adapted to the low light and cool temperature regime of their environment, they may be more plastic to environmental change at low ranges, especially temperature, than expected.

Experiments were carried out *in situ* on Campbell Island to ascertain the effect of environmental perturbations, using carbohydrate, chlorophyll, and growth analysis of leaves on *P. speciosum*, *P. hookeri* and *P. criniferum*, *Bulbinella rossii*, and *A. latifolia*. The microenvironment around each plant was altered by combinations of reducing light, increasing shelter, increasing nutrients, altering photoperiod and increasing temperature over the course of eight weeks. Most of the treatments had very little effect on the carbohydrate pools of the species suggesting that environments were not limiting growth on the island. However leaf growth in *P. criniferum* increased in reduced light as did leaf growth in *B. rossii*, suggesting etiolation (sensitivity to light). *A. latifolia* showed an increase in carbohydrate pools with increase in temperature, compared with *P. speciosum*. Contrary to expectations increased night length also had a small positive effect on growth. Chlorophyll content remained unaffected by treatment but differed significantly between species (ranging from 56 mg g^{-1} in *A. latifolia* to 149 mg g^{-1} in *B. rossii*). These results suggest that the megaherbs are quite plastic in their responses, relatively unaffected by environmental perturbations.

Megaherbs may be pollen limited in an environment that might be considered unfavourable to insects. 15 plants each of *P. criniferum* (discoid capitulum), *P. speciosum* (rayed capitulum) and *P. criniferum x speciosum* (rayed capitulum) were randomly chosen and four treatments - control, bagged and hand-outcrossed, bagged and hand-selfed, and bagged (no assisted pollination) - individually applied to four scapes on each plant. Capitula were collected at the end of the season and proportion of seed set analysed in the laboratory. *P. speciosum*, the most colourful of the genus, is an obligate out-crosser (*i.e.* self-incompatible). The less colourful *P. criniferum* is autonomously self-compatible, and the hybrid, while being able to set seed autonomously, sets more seed when outcrossed. These results indicate that these plants are not pollen or pollinator limited. Observations showed that small midges were the most active on these plants, although their efficacy was not examined. Their activity was significantly affected by wind. A selection of breeding systems and the existence of a hybrid suggests a capacity for recombination of genetic material and potential for adaptive radiation of species.

This study shows that the subantarctic megaherbs are well adapted to their environment. Their apparent plasticity in physiological responses to environmental, and their range of breeding systems, also indicates that they may be more adaptable to novel environments than previously considered. However, whether they are relicts of an ancient, more widespread flora, or whether they have evolved more recently *in situ* remains unresolved.

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