The cost of branching out: photosynthetic properties of *Prumnopitys taxifolia*, a divaricate New Zealand shrub

Antigone Mitchell, 2013

Isolated from the rest of the world, the islands of New Zealand developed distinctive flora and fauna. Although not unique to New Zealand, two traits, heteroblasty and divarication, occur with uniquely high frequency among the islands’ endemic plants. Heteroblasty, adopting more than one distinct growth form during maturation, occurs in about 10% of all seed plants in New Zealand (Gamage 2011). Similarly, divarication, or a wide-angled branching pattern, occurs in 10-20% of all woody species on the islands (Bond *et al.* 2004, Atkinson and Greenwood 1989, Greenwood and Atkinson 1977). These divaricate plants are often shrubs with thin, wiry, almost bare outer branches forming a cage-like structure around inner, leafy branches. Often, these divaricate shrubs are the juvenile form of heteroblastic plants.

Many researchers have explored why these traits occur with such high frequency in New Zealand and two main hypotheses have emerged. The first attributes divarication to New Zealand’s variable and often harsh climate. Proponents of this hypothesis believe that the cage-like structure of outer branches protects the leafy, inner branches from factors such as frost, wind, and high intensity light (Kelly and Ogle 1990, Mcglone and Webb 1981). The second hypothesis suggests that divarication evolved in response to browsing by the now-extinct moa, large, flightless birds, which were the primary browsers on the islands. The flexibility of the divaricate branches would have made it difficult for the moa to detach branches and the wide-angles of the branches would have made them difficult to swallow (Bond *et al.* 2004, Atkinson and Greenwood 1989, Greenwood and Atkinson 1977).

While evidence in support of either hypothesis can be found, both are founded on a couple of key assumptions. The first is that the divaricate form is costly. Both hypotheses assume that the almost bare, outer branches conduct no or limited photosynthesis and that their main purpose is to protect the inner, leafy branches. This costliness could explain why many divaricate plants adopt a distinct adult form – once the plants have grown large enough to escape the dangers of either climate or moa-browsing, they shed the costly juvenile form in favor of a more productive adult form. Preliminary studies of *P. taxifolia*, a heteroblastic New Zealand plant that is divaricate in its juvenile form, however, have shown that the outer, divaricate branches *are* photosynthetically active. This summer I have explored just how productive these outer branches are, especially in comparison to the leafy inner branches, to determine whether the assumptions of previous researchers are valid.

To do this, I used a Li-COR gas exchange system (LiCor 6400) to determine the rate of photosynthetic CO$_2$ uptake over the natural range of light intensities of the almost bare outer branches and the leafy inner branches of *P. taxifolia*. During photosynthesis, plants take carbon dioxide (CO$_2$) from the air and convert it into sugars. By determining how much CO$_2$ is taken from the air, the Li-COR can determine the rate of photosynthesis. These gas exchange analyses confirmed that the outer branches are productive and that they perform about half as much photosynthesis as the inner, leafy branches (Figure 1). This indicates that they may not be as costly an adaptation as has been assumed.

**Figure 1**

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<tr>
<th>Light Intensity (µmol m$^{-2}$ s$^{-1}$)</th>
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<tr>
<td>Photosynthetic Rate (µmol CO$_2$ m$^{-2}$ s$^{-1}$)</td>
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<tr>
<td>Twiggy Shoots</td>
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<td>500</td>
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Faculty Mentor: Barry Logan

Funded by the Surdna Fellowship
References


LiCor 6400. Lincoln, Nebraska, USA.