Carbon Acquisition in Variable Environments: Aquatic Plants of the River Murray, Australia

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Declaration

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Abstract

This thesis considers the implications of changes in the supply of resources for photosynthesis, with regard for modes of carbon acquisition employed by aquatic plants of the River Murray. Carbon supplies are inherently more variable for aquatic plants than for those in terrestrial environments, and variations are intensified for plants in semi-arid regions, where water may be limiting. In changeable environments the most successful species are likely to be those with flexible carbon-uptake mechanisms, able to accommodate variations in the supply of resources.

Studies were made of plants associated with wetland habitats of the Murray, including *Crassula helmsii*, *Potamogeton tricarinatus*, *P. crispus* and *Vallisneria americana*. The aim was to elucidate the mechanisms of carbon uptake and assimilation employed, and to determine how flexibility in carbon uptake and/or assimilation physiology affect survival and distribution. Stable carbon isotopes were used to explore the dynamics of carbon uptake and assimilation, and fluorescence was used to identify pathways and photosynthetic capacity. The studies suggest that physiological flexibility is adaptive survival in changeable environments, but probably does not enhance the spread or dominance of these species.

*V. americana* is a known bicarbonate-user, and it is shown here that it uses the Crassulacean Acid Metabolism (CAM) photosynthetic pathway under specific conditions (high light intensity near the leaf tips) concurrently with HCO$_3^-$ uptake, while leaves deeper in the water continue to use the C$_3$ pathway, with CO$_2$ as the main carbon source. However, *V. americana* does not use CAM when under stress, such as exposure to high light and temperature. The diversity of carbon uptake and assimilation mechanisms in this species may explain its competitive ability in habitats associated with the Murray. In this way it is able to maximise use of light throughout the water column. In shallow, warm water, where leaves are parallel to the surface, CAM ability is likely to be induced along the length of the leaf, allowing maximal use of carbon and light.

The amphibious *C. helmsii* is shown to use CAM on submergence, even where water levels fluctuate within 24 hours. This allows continued photosynthesis in habitats where level fluctuations prevent access to atmospheric CO$_2$. It appears that stable conditions are most favourable for growth and dispersal, and that the spread of *C. helmsii* is mainly by the aerial form.

Carbon uptake by *P. tricarinatus* under field conditions is compared with that of *P. crispus* to demonstrate differences in productivity associated with aqueous bicarbonate and atmospheric CO$_2$ use. *P. tricarinatus* uses HCO$_3^-$ uptake to promote growth toward the surface, so that CO$_2$ can be accessed by floating leaves. Atmospheric contact provides access to light and removes the limitation of aqueous diffusive resistance to CO$_2$, thereby increasing photosynthetic capacity above that provided by submerged leaves.
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