

Soil salinity: a driver in macroevolutionary processes?

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Recent evidence from Australia, one of the most biologically diverse areas of the world, with one of the most extensive arid zones and widespread natural salinity, suggests a role for soil salinity in biogeography and ecology. The distribution of plant species in Queensland responds strongly to a geochemical gradient as expressed by soil salinity and pH, starting at levels of salinity much lower than those for saline soil [1]. Statistical modelling shows that adding soil salinity to climatic and other soil variables in a Generalized Additive Model to account for site scores from a correspondence analysis of site by species data improved the results dramatically (Mean Squared Error decreased from 0.89 to 0.65 and R^2 improved from 0.41 to 0.57) [1]. Three *Acacia* species (*Acacia harpophylla* (commonly called 'brigalow'), *A. cambagei* and *A. argyrodendron*) that exhibit high salt tolerance are closely related species of microneurous *Plurinerves* as indicated by *Acacia* systematics [2].

Parallel investigations of thrips systematics and their behavioral ecology have shown that: 1) there are specific host-plant relationships of elongate and round gall thrips (*Kladothrips* spp.) on the *A. harpophylla* clade of *Plurinerves*; 2) phyllode-glueing thrips also show host specificity; and 3) thrips on *A. harpophylla* and *A. cambagei* display high species richness [2, 3]. Chronological phylogenetic analyses indicate that the approximate age of origin of gall thrips (*Kladothrips* spp.) is Miocene and that their subsequent diversification is closely linked to host-plant evolution [3]. Host affiliation with *Plurinerves* has been estimated to date from 7.5 My with a pronounced diversification episode for gall-thrips lineages affiliated with *Plurinerves* hosts between 3 and 6 My [3]. Aridity developed across Australia in the late Miocene [4]. The *A. harpophylla* clade of *Plurinerves* with host-specific gall-inducing *Kladothrips* occurs on alkaline and/or saline substrate throughout Australia. Other *Plurinerves* occur in a range of different habitats. Thus congruence between plant and insect phylogenies and co-speciation are apparent. While adaptive radiation may be a response to climatic change, more proximal environmental drivers include aridity, alkalinity, and salinity.

Independent lines of evidence—phytogeography, plant and insect systematics, and insect behavioral ecology—point to a potentially important role for soil salinity in macroevolutionary processes for the genus *Acacia*. The potential role of substrate chemistry in macroevolutionary processes should be investigated for other genera found in arid environments.

[1] Bui & Henderson (2003) *Austral Ecology* **28**, 539-552. [2] Crespi, Morris & Mound (2004) *Evolution of ecological and behavioural diversity: Australian Acacia thrips as model organisms*. CSIRO, Canberra. [3] McLeish et al. (2007) *BMC Biology* **5**, 3. doi:10.1186/1741-7007-5-3. [4] Martin (2006) *Journal of Arid Environments* **66**, 533–563.

Sulphur and carbon isotope records across the terrestrial Permian-Triassic (P-T) boundary

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The end Permian mass extinction (~ 252 Ma [1]) is known as the greatest biotic crisis in earth history with the disappearance of more than 90% of marine species and 70% of terrestrial vertebrate families [2]. To better understand the interaction of the carbon and sulphur cycles across the terrestrial P-T boundary, we collected 27 sedimentary rock samples at average resolution of 35 cm and 9 carbonate nodules along a section of ~10 meters in Karoo Basin, South Africa. We determined carbon and sulphur contents as well as carbon and sulphur isotope records of above samples.

The organic carbon contents of sedimentary rocks are quite low, less than 0.04 wt %. The average $\delta^{13}\text{C}$ value of organic carbon is around -25‰ throughout the section, but at 59 cm before the P-T boundary, this value increases to -23.8‰ and drops sharply to -26.5‰ over a distance of 110 cm. The background value of -25‰ is recovered within 19 cm. The $\delta^{13}\text{C}$ values of carbonate nodules in the ~3 m preceding the boundary are around -8.5‰, while those found in the ~5 m after the boundary are around -11.5‰. Total sulphur contents of sedimentary rocks are generally less than 0.01 wt%, with the exception of a sharp peak of ~0.45 wt % at 5 cm above the boundary. Although their full pattern is noisier than that seen in the $\delta^{13}\text{C}$ record, the $\delta^{34}\text{S}$ values of Cr(II)-reducible sulphides and different sulphate species (water-soluble, acid-soluble, and acid-insoluble sulphates) all decrease by at least 8‰ within the 100 cm after the boundary.

The negative shifts of both $\delta^{13}\text{C}_{\text{carbonate}}$ and $\delta^{13}\text{C}_{\text{organic}}$ ($\approx -3\text{‰}$) at the boundary indicate a decrease in the ^{13}C content of carbon input into the P-T terrestrial system. Likewise, the sharp peak of total sulphur content coinciding with the boundary suggests a rapid addition of sulphur into the terrestrial environment. The shared initial decreases in $\delta^{34}\text{S}$ values suggest that this sulphur was depleted in ^{34}S . Multiple sulphur isotope compositions ($\delta^{34}\text{S}$ and $\Delta^{33}\text{S}$) of the different sulphate species are generally equivalent, indicating a shared sulphate source throughout the section. While the $\delta^{34}\text{S}$ values of the Cr(II)-reducible sulphides are compatible with bacterial sulphate reduction, the associated $\Delta^{33}\text{S}$ values are more negative than those typically associated with this process. Although the $\delta^{13}\text{C}$ and $\delta^{34}\text{S}$ records imply the coherent transfer of ^{13}C - and ^{34}S -depleted material to the PT terrestrial environment, the $\Delta^{33}\text{S}$ values complicate a straightforward identification of the source of this material.

[1] Shen et al. (2011) *Science* **334**, 1367-1372.

[2] Erwin (1994) *Nature* **367**, 231-235.