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2007

## Indigenous plant recruitment limitation by bitou bush (*Chrysanthemoides monilifera* spp. *rotundata*): effect on life history stages and allelopathic mechanisms

Emilie-Jane Ens

*University of Wollongong*

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# Indigenous plant recruitment limitation by bitou bush (*Chrysanthemoides monilifera* spp. *rotundata*): effect on life history stages and allelopathic mechanisms

A thesis submitted in fulfillment of the requirements for the award of the degree of

Doctorate of Philosophy

From the School of Biological Sciences

University of Wollongong

by

Emilie-Jane Ens B. Sc. (Hons)

2007



Indigenous coastal vegetation



Bitou bush invasion



Regenerating bitou bush

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## Abstract

Exotic plant invasion, the consequent displacement of indigenous flora and subsequent effects on ecosystem health has become of increasing concern to land managers, conservationists and government agencies. Despite the concomitant attention of ecologists and invasion biologists, our empirical understanding of the impacts and mechanisms of exotic plant invasion remains rudimentary and fragmented and further complicated by species and site specific effects. Exotic plant invasion is of paramount concern in Australia due to the high species endemism and the recent settlement of Europeans (in 1788) which has been paralleled by vast, rapid modification of the landscape. Large expanses of land have subsequently been cleared for agriculture, residential and industrial areas and many exotic species have been introduced, both intentionally and accidentally. As a result, exotic species invasion has become an issue of national significance.

In attempt to further our ecological understanding of the impacts, and macro and micro-mechanisms of exotic plant invasion, I have focused my research on the bitou bush (*Chrysanthemoides monilifera* spp. *rotundata* (DC.) T. Norl.) invasion of the eastern Australian coastal dune systems. Bitou bush has been declared Australia's sixth worst weed based on its invasibility and impacts on the environment. However there is a paucity of quantitative evidence to support these claims with substantiation being primarily anecdotal. Therefore I aimed to investigate the plant demographic impacts and soil chemistry changes imposed by the invasion and determined whether allelopathy and indirect soil chemical interference are mechanisms facilitating bitou bush invasion in Australia.

The demographic response of indigenous plants to the invasion of exotic woody plants has rarely been quantified. I therefore aimed to determine which life history stages of three indigenous plant species: *Correa alba* var. *alba* (Andrews; Rutaceae), *Monotoca elliptica* ((Sm.) R.Br.; Epacridaceae) and *Lomandra longifolia* (Labill.; Lomandraceae), were more susceptible to the invasion of bitou bush. I also assessed whether various morphological and physiological parameters of the mature stage of these species were affected by the presence of bitou bush. Populations of all three indigenous species in bitou bush invaded habitats had significantly fewer small individuals and a lower population density than populations in non-invaded habitats. The mean flower production, growth, ratio of reproductive: vegetative buds and physiological stress of mature individuals of each of these species in bitou bush invaded habitat did not differ from those in the non-invaded habitat. However, the flower production of *C. alba* was significantly more variable in the bitou bush invaded habitat which suggested plasticity in resource allocation in response to the invasion. Increased trait variability was not found for *M. elliptica* and *L. longifolia* suggesting mature plant tolerance to the new neighbour. We therefore propose that bitou bush affected indigenous plant populations primarily by preventing recruitment through the germination or seedling growth stages and that older plants typically tolerated the presence of the exotic. The reduction in indigenous plant recruitment is likely to create space that would facilitate bitou bush monoculture formation in the new host environment.

A more detailed assessment of the physiological health of mature indigenous plants in invaded habitats was conducted to determine whether there was seasonal effect of the invasion. The photosynthetic efficiency of plants was adopted as an indicator of physiological health. The seasonal photosynthetic patterns of *C. alba*, *M. elliptica* and *L. longifolia* in invaded and non-invaded habitats were assessed using chlorophyll



fluorescence. I also examined whether bitou bush altered the habitat physico-chemical parameters which may have lead to any observed changes in the physiological health of mature individuals. All three species exhibited photosynthetic maxima during winter and minima in summer, in contrast to most other Northern hemisphere studies on seasonal photosynthetic patterns. Winter photosynthetic maxima are likely to be facilitated by the autumn rains and cooler winter temperatures of the eastern Australian coast. Differences in the photosynthetic capacity of individuals of all three species among different sites were also detected. Although the invasion of bitou bush significantly altered the canopy cover of *C. alba* and *M. elliptica* and moderated the ground level microclimate, I detected no effect on the seasonal photosynthetic patterns of the three species studied, suggesting physiological tolerance to the invasion by mature plants. The reductions in ground incident light and daily maximum temperatures associated with the invasion were likely to be responsible for the reduction in variability of Fv/Fm (physiological stress parameter) detected in autumn for all species. Therefore, I suggest that the photosynthetic patterns of Australian native plants is a function of seasonal climatic and site variability, which was not significantly affected by the microhabitat changes induced by the invasion of bitou bush.

Chemical interference is increasingly suggested as a mechanism facilitating exotic plant invasion. I therefore devised a comprehensive bioassay technique that promoted detection and differentiation of phytotoxicity, allelopathy and indirect soil effects of exotic plants by comparing extract inhibition with that of a dominant indigenous plant. Comparison of the bioactivity of comparable extracts from plant parts and soil was integral to the technique. Hydrophilic to hydrophobic solvent extracts of indigenous acacia and exotic bitou bush leaves and roots all exhibited differential phytotoxic effects on a range of

indigenous plants. Chemical interference, or allelopathy, between co-evolved plants was found by the hydrophobic extracts of the roots and soil of acacia against a sedge, *Isolepis nodosa* (Rott.) R. Br. Hydrophobic and hydrophilic extracts of the roots and soil from the exotic bitou bush elicited allelopathic effects against four indigenous species. Additionally, the hydrophobic soil extracts of bitou bush inhibited the germination and growth of *Banksia integrifolia* and *A. longifolia* var. *sophorae*, while the acacia soil extract inhibited the germination of *B. integrifolia* and *Lomandra longifolia*. Therefore I suggest that both the indigenous acacia and exotic bitou bush have the potential to chemically inhibit the establishment of indigenous plants, with an additive effect. Eventual monoculture formation by bitou bush is likely to be facilitated by allelopathy against indigenous species and the residual soil inhibition of dominant *A. longifolia* var. *sophorae* establishment.

To determine whether bitou bush exuded novel compounds into the soil that were not present in the acacia dominated indigenous system, I compared the root and soil chemical profiles of these species. I focused on the hydrophobic extracts of the roots and soil as these were found to be most inhibitory in the laboratory based bioassays. Using solvent based extraction and gas chromatography – mass spectrometry (GC-MS) techniques, I detected three compounds that were exclusive to the bitou bush root and soil, and seven compounds that were common to the bitou bush and acacia roots but only present in the bitou bush soil. The compounds unique to the bitou bush invaded soil were all sesqui- and diterpenes. Several of these compounds were found to inhibit the seedling growth of a native sedge, *Isolepis nodosa*. Of particular interest were the sesquiterpenes:  $\beta$ -maaliene,  $\alpha$ -isocomene,  $\beta$ -isocomene,  $\delta$ -cadinene, 5-hydroxycalamenene and 5-methoxycalamenene which were found in high concentrations in the bitou bush root and soil and exhibited phytotoxic activity.

To confirm that bitou bush alters the soil chemistry of the sand dunes of the eastern Australian coast, we also designed a novel technique to assess the field soil chemical profile. The technique employed adsorbent resin filled bags intended to trap hydrophobic compounds in-situ which were then tested for bioactivity in the laboratory. I compared the hydrophobic chemical profile of soil below bitou bush and acacia to that of unvegetated soil. Similar GC profiles were found to those detected via the solvent extraction method; however, the resin bag technique showed that the alkane series was present in both the bitou bush and acacia soils. Using the resin bag technique, the chemical profile of the bitou bush invaded soil was characterised by a high concentration of sesquiterpenes and was distinct from the indigenous plant soil and bare sand, which were similar except for the presence of a higher concentration of phenolic compounds in the acacia soil and a higher concentration of hexadecanoic acid in the un-vegetated soil. Bioassays of these hydrophobic mixtures showed that the soil inhabited by plants, whether exotic or native, was inhibitory to the growth of an indigenous sedge, compared to the unvegetated soil.

Based on the series of experiments conducted, and described above, I suggest that the bitou bush invasion of the eastern Australian coast is likely to affect the recruitment limitation of indigenous species, rather than effects on fecundity and mature plant health. Bitou bush was found to induce a unique soil hydrochemical chemical profile, via two different techniques, which was characterised by high concentrations of several sesquiterpenes and low concentrations of a phenolic compound compared to the acacia profile. Although hydrophobic extracts both the bitou bush and acacia soils inhibited the growth of some indigenous species, the bitou bush inhibited more, including the dominant acacia, which is likely to result in the creation of vacant space and increased opportunities for bitou bush establishment and hence proliferation. Therefore, I suggest that allelopathy is

a key mechanism driving the recruitment limitation of indigenous flora and invasion of bitou bush on the eastern Australian coast.

## **Acknowledgements**

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