COMPARISON OF THE ECOLOGY OF BITOU BUSH AND BONESEED (*CHRYSANTHEMOIDES MONILIFERA*) IN SOUTH AFRICA AND AUSTRALIA

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Summary. The ecology of the biological control targets, bitou bush, *Chrysanthemoides monilifera rotundata*, and boneseed, *C. monilifera monilifera* in their native habitat, South Africa, are compared with weed infestations in their country of introduction, Australia. Taxonomic and distribution differences between bitou bush and boneseed implies that two sets of agents will be required. Boneseed and bitou bush plants in South Africa produced significantly less seed than in Australia. For bitou bush this was largely due to fewer flowers. Mature plant densities can however be similar in the two countries. Biological control aimed at reducing flower numbers through herbivory, would reduce seed set and also reduce competition with native flora in Australia. Control of infestations in Australia will require combining biological control with management, probably by fire.

INTRODUCTION

The southern African shrubs, bitou bush, *Chrysanthemoides monilifera rotundata* and boneseed, *C. monilifera monilifera*, are weeds in Australia and are the targets of a biological control program. Their importance and ecology in Australia was established in a number of studies (17, 18, 20, 21). Comparisons of plant abundance have been made between *C. monilifera* in South Africa and Australia (16, 19), although the South African plants used in the comparison, from Knysna on the south coast of Cape Province, were probably *C. monilifera pisifera*, a subspecies not found in Australia (4, Scott, unpublished observations). Reports that *C. monilifera* was much less abundant in its native region of southern Africa (16, 19) and that the plant is attacked by insects likely to be host specific (10) has lead to a search for biological control agents. The ecology of bitou bush and boneseed was studied during the search for biological control agents in South Africa. In this paper I make a comparison, in the context of biological control, of the distribution and abundance of these weeds in their native habitat, South Africa, with that of the weeds in their country of introduction, Australia.

METHODS

Information of the ecology of bitou bush and boneseed in Australia was obtained from published sources. The ecology of bitou bush and boneseed in South Africa is based on study sites monitored from 1987 to 1989 (1, Scott unpublished). Boneseed was studied at two sites: Devil's Peak and St James in Cape Province. Bitou bush was studied at five sites in Natal: The Bluff, Palmiet, Mtunzini, Nseleni and St Lucia. Flowers and seeds were counted on 20 randomly chosen plants at three month intervals at each site. Seedlings and mature plant were counted during the study and seed bank densities were measured at the end of the sampling period. Full details of this study will be reported elsewhere (Scott unpublished).

RESULTS AND DISCUSSION

Taxonomy. Identification of *Chrysanthemoides* subspecies is simpler in Australia than in South Africa where there are at least 7 taxa and different forms and intergrades between forms (4, 12). Bitou bush and boneseed only overlap in the Ulladulla - Sydney region in Australia, but

hybridization appears rare (15). Hybrids are not known from South Africa where bitou bush and boneseed are geographically widely separated (12). There are considerable morphological differences between the two subspecies as illustrated by Norlindh (12). Thus it is likely that studies of the genetic variability of bitou bush and boneseed will show that they are separate species. The difference between bitou bush and boneseed also implies that two sets of biological control agents will be required.

Distribution. Bitou bush in Australia is considered to have only occupied part of its potential range (5) when compared to the distribution in South Africa (12). In contrast, boneseed appears to occupy a wider range of climates and habitats in Australia than in South Africa. In Australia boneseed is found in Mediterranean type and temperate climates in South Australia, Victoria and NSW. In South Africa the plant is restricted to the south west Cape Province that has a Mediterranean type climate (12, Scott unpublished). The wide range of climates in which bitou bush and boneseed are found also implies that it is unlikely that a single biological control agent will be effective across the entire range. For this reason several agents are being selected from a wide range of climates, including climates where boneseed is not present in South Africa, but matched to Australian conditions (2).

There is no obvious difference between the soil type preference of bitou bush in Australia and South Africa. Plants in both regions are found on sandy or low fertility soils of granitic or sedimentary origin and on coastal soils (8, 18). Boneseed is found on sandy or low fertility soils of granitic or sedimentary origin and on coastal soils in Australia (18). In contrast, boneseed in South Africa is largely restricted to mid slopes of mountains and lithosols on sandstone, whereas other *Chrysanthemoides* species such as *C. incana* and *C. m. pisifera* are found on the coastal plain (Scott unpublished). The extent to which the distribution is determined by biotic factors such as pathogens or insects or intra-specific competition has not been investigated. Given the wider distribution in Australia, biological control agents found in both coastal and mountain habitats (eg *Comostolopsis germana* and *"Tortrix"* sp.) (1, 14) could be more effective than agents with more restricted distributions (eg some of the chrysomelids).

Phenology. Boneseed has a similar flowering phenology in Australia and South Africa (Table 1). However, because of its relatively short flowering period, alternative hosts may be important to enable a build-up of populations of seed predators such as *Mesoclanis* spp. (9) and for their survival during the non flowering period. *C. incana* and *C. m. pisifera* found near boneseed in South Africa extend the availability of flowers and seed by three months. These plants are absent from Australia. Noble and Weiss (11) point out that to be successful biological control agent, a seed predator would need to cause greater than 95% seed reduction over the entire year and that control would be unsatisfactory if it dropped to less than 90% during part of the year (especially during abundant seed production). Build-up of flower destroying insects and seed predators is more likely to occur on bitou bush because the plant flowers for more of the year than boneseed (Table 1).

Seed production. Although boneseed plants in South Africa and Australia produce similar numbers of ovules per capitula, an order of magnitude less seed is produced in South Africa (Table 1). This order of difference continues into the seed bank. Unfortunately there are no published data available from Australia to extend the comparison as far as mature plants.

More of a comparison is possible for bitou bush. Similar numbers of ovules are formed on the capitula in both countries (Table 1). However in South Africa, the canopy produces a fifth of

the capitula and these in turn have a third less seed maturing in comparison with Australia. These differences are carried through into the seed bank and seedlings numbers. There are more plants in South Africa than would be expected given the differences in seed production. This may be due to self thinning of seedlings to the same mature plant density. Plants in South Africa covered less surface area than in Australia. This is likely to be due to the greater range of herbivores present, some of which are being used as biological control agents (eg *Comostolopsis germana*).

Table 1. Comparison of bitou bush and boneseed ecology in southern Africa and Australia. Unsourced data from South Africa come from Scott (unpublished). South African data shows means ± S.E. for the Devil's Peak population of boneseed (N = 20) and means ± S.E. of five populations of bitou bush. Australian data are ranges or means ± S.E. from published sources.

Plant characteristic	South Africa	Australia (Source)
Boneseed		
Flowers	July - Oct.	Aug. - Oct. (18, 17)
Ovules/capitulum	6.5 ± 0.14	5 - 6 (15)
Ripe fruit	Nov. - Feb.	Nov. - Feb. (18)
Seed/m^2 canopy	127 ± 32	3025 ± 450 (17)
Seed bank under plants, seeds/m^2	70 ± 22	800 - 2500 (6)
Seedlings/m^2	0 (unburnt) 1.4 ± 0.2 (burnt)	47 ± 18 (unburnt) 826 ± 255 (burnt) (6)
Bitou bush		
Flowers	Apr. - Nov.	Apr. - Nov. (18)
Ovules/capitulum	11.6 ± 0.2	11 - 13 (15)
Capitulum/m^2 of canopy	164 ± 77	1010 ± 170 (19)
Ripe fruit	Apr. - Jan.	All year (June - Sept.) (17)
Mature seeds/capitulum	2.1 ± 0.35	6.6 ± 0.3 (19)
Seeds/m^2 canopy	924 ± 444	3545 ± 600 (17)
Seed bank under plants, seeds/m^2	37 ± 14	2030 ± 460 (19)
Seedlings/m^2	0.03 ± 0.02 (unburnt)	114 ± 27 (unburnt) (17) 40 ± 16 (burnt)
Plants/m^2	0.2 ± 0.04	0.2 (17), 0.67 (20)
% ground cover	25.6%	37.6% (20)

Biological control. Fire will have a major impact on the biological control program. Boneseed does not resprout after fire in South Africa or Australia (6) and depends on the soil seed bank for regeneration. Lane and Shaw (7) found that boneseed had no seed bank remaining after fire. This also appears to be the case in South Africa. Seedlings appeared following a fire at the Devil's Peak study site, but not in the next year. In contrast to boneseed, 26% of mature bitou bush resprouted in Australia (17) although fire caused loss of seed (17). Fire appeared to have a similar effect on bitou bush in South Africa (Scott unpublished). The seed of bitou bush and boneseed rapidly lose viability in the soil. Weiss (17) reported the percentage viable seed for bitou bush and boneseed after three years to be 2% and 13% respectively. Plants at the South African study sites were mostly of similar age (as estimated from annual growth rings), indicating episodic recruitment, probably following fire (Scott unpublished). Fire combined with seed predation could effectively control populations (11).

The difference in bitou bush seed production between South Africa and Australia results from a lower density of capitula in South Africa (Table 1). A number of biotic factors could be responsible including *C. germana* which has already caused a reduction in flowering in Australia (13). Seed predators such as *Mesoclanis* species were not abundant at the sites and during the sampling period destroyed up to 9% of potential seed. Further studies using insect exclusion experiments (3) could show the role of herbivory in reducing seed production in South Africa. It would be expected that the growth ring increments, which are very evident in *Chrysanthemoides*, would also increase in size once the plant was freed from herbivory in South Africa. Among the first changes to be expected from successful biological control in Australia would be a reduction in capitula number and a reduced growth ring increment. It will still be necessary to manage infestations, probably by fire, to ensure the removal of stands of dense bitou bush and boneseed once there has been a significant depletion of the seed bank.

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