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AGE DETERMINATION AND THE EFFECTS OF HERBIVORY ON *ACACIA ANEURA* (MULGA) IN THE CHENOPOD SHRUBLANDS OF SOUTH AUSTRALIA

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ABSTRACT

Previous research suggests that various arid zone woody plant species are destined for extinction due to selective elimination of their seedlings. In *Acacia* the absence of these seedlings is thought to be due to herbivory by introduced herbivores. A method whereby plant age is estimated from a relationship with plant dimensions was verified for *A. aneura* and shown to be transferable to other regions with similar soil and climate characteristics in northern South Australia. The method was used to develop age profiles for 81 populations of *A. aneura*. Correlation of age profiles with grazing history shows that sheep and cattle are the most significant herbivore affecting populations of *A. aneura* in northern and eastern South Australia. No effect was found for rabbits and other herbivores. Grazing management regimes in pastoral areas must be modified to prevent the decline of *A. aneura* populations.

INTRODUCTION

Acacia aneura (mulga) has an extensive distributional range, covering 1 500 000 km ^{2} or 20% of the Australian continent (Everist 1971). It is important to the pastoral industry through four states: Queensland; New South Wales; South Australia; Western Australia, and the Northern Territory (Randell 1992). The impacts of grazing on the species have been reported from many parts of Australia (Crisp 1978; Hodder and Low 1978).

A method of investigating the effects of grazing on long-term regeneration of trees and shrubs is by correlating environmental variables and grazing pressure with age profiles. This is made more precise if the age of individual plants can be determined. If grazing pressure has influenced seedling survival, younger shrubs should be present at densities lower than expected for maintenance of the population (Moore 1976; Tiver and Andrew 1997).

A method of estimating plant age from the relationship between the dimensions of the plant and its age was developed and used by Crisp and Lange (1976) and Crisp (1978). Crisp (1978) found a linear relationship between the age of individual *Acacia aneura* and an index of size (based on canopy diameter and height) at Koonamore, South Australia. From this relationship, the age of any individual mulga could be estimated.

The aim of this study was to determine if Crisp's (1978) methods of ageing *Acacia aneura* individuals could be applied to other regions and, if so, to further assess the effects of herbivory on *A. aneura*.

DETERMINING AGE AND INDEX OF SIZE RELATIONSHIPS

The relationship between plant dimensions and age can be investigated where the ages of a population of individuals are known. The ages of many *Acacia aneura* individuals were determined through consultation with the manager of Roxby Downs Station who has lived in the district for many years. All trees whose ages were known were measured using the technique outlined by Crisp and Lange (1976) and Crisp (1978). Height (H) and maximum canopy diameter (D) measurements were taken from each individual surveyed, and a single index (I) was calculated by summing H and D.

The sample of plants at each site constitutes an independent sample for a given age, as no plant was selected for any characteristic other than that its known age, and no plant of known age was omitted. A regression analysis was performed, yielding a straight line fit to the observations (Figure 1). It is obvious in spite of the scattered nature of the data, that the regression is a significant explanation of the variation.

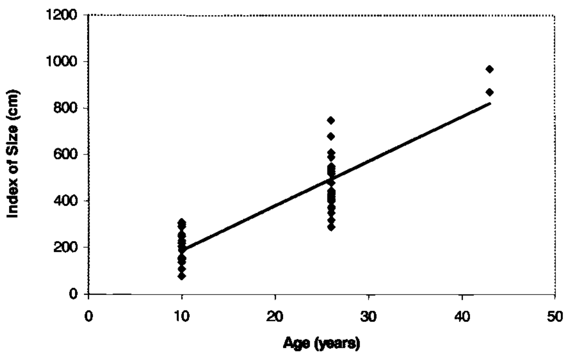

Figure 1: The relationship between the age (years) and the index of size (cm) for 38 individual mulgas at Roxby Downs in northern South Australia. The calculated age coefficient = 19.17, standard error = 1.774, F = 116.78, p = < 0.0001 and r^2 = 0.76. The two trees aged 43 years on the far right of the figure have a high influence on the regression line; however the overall coefficient of determination for this regression is high (76%).

The age coefficient for this study was determined from the linear relationship between the age and index of size and compared to the age coefficient of a similar study at Koonamore by Crisp (1978) where 423 size measurements were taken over 47 years from nine *A. aneura* individuals. This allowed the development of a relationship between the age and index of size. Crisp's relationship may be written as:

$$\text{Index} = 20.66\ \text{age} - 58.05 \qquad (1)$$

This is to be compared with the results of our study:

$$\text{Index} = 19.17\ \text{age} - 3.0685 \qquad (2)$$

No significant difference was found in the comparison of the age coefficients using a t-test (t = - 0.84; df = 36; P = 0.41). This result can be regarded as confirmation of the age coefficient produced by Crisp (1978) which was obtained from a very large sample of observations (423), but on only nine independent individual plants. Our study has extended this to a much larger sample of plants at a different location but with similar characteristics so the Crisp coefficient can now be regarded as having greater applicability to locations with similar conditions.

GRAZING IMPACTS ON *ACACIA ANEURA*

A stratified technique similar to that of Graetz (1978) was used to select 81 mulga groves at Roxby Downs and Koonamore Station, subject to a range of past and present herbivore densities. This technique was more efficient than a random procedure for locating sufficient numbers of ungrazed and lightly grazed populations of *Acacia aneura*, which occur at low frequencies in the landscape (Tiver & Andrew 1997). Background effects due to invertebrate herbivores and other unmeasured environmental variables were assumed to be relatively constant.

Populations were sampled by a modified 'random walk' method (Kent and Coker 1992). At each site populations of *Acacia aneura* were scored into one of nine possible life stage classes following Tiver and Andrew (1997). Standing dead and deadfall individuals were included as classes because, although not part of the living population, they can give a good indication of past history of the population (Ogden 1985; Tiver & Andrew 1997).

Seven herbivory variables were recorded at each site. Grazing history was determined from a number of sources, including stocking records held at the Pastoral Management Board of South Australia, distance to the nearest watering point and direct observations of tracks and egesta at the study sites. Variables for sheep and cattle grazing prior to 1955 where based on the distance to historical watering points as obtained from pastoral maps. The location of old wells was particularly important when livestock were herded and kept in large numbers, as this resulted in greater impacts around watering points.

Principal Component Analysis (PCA) was used to find linear combinations of life stages, which account for the variability between sites. These linear combinations reflect profiles of life stages that differ from site to site. Three components (axes) accounted for the majority of the variation, with axes 1, 2 and 3 accounting for 26.7, 18.9, and 13.4 percent of the variance respectively. The site scores from the PCA should be sensitive to grazing pressure if grazing pressure has had an influence on the profile of life stages present at a particular site. Chi-square analysis was used to find correlations between the PCA scores (life stage profiles) and grazing pressures. Profile scores from the PCA axes were classed into intervals and contingency tables generated for profiles against the associated grazing pressure variables recorded for each site. The grazing variables (cells) in the table were aggregated if necessary to meet the minimum sample requirements of a valid chi-square test without seriously compromising ecological information.

In each case the aggregated grazing pressure scores now reflect the presence or absence of grazing pressure. PCA axis 1 and 3 showed no significant association with any of the grazing pressure variables. PCA axis 2 scores showed significant association with sheep grazing 1955–1983 (χ^2 = 11.032; df = 2; p = 0.004), cattle grazing 1955–1983 (χ^2 = 6.945; df = 2; p = 0.031), and sheep grazing 1984–1988 (χ^2 = 14.041; df = 2; p = 0.0009).

PCA Axis 2 indicates a contrast between regenerating and non-regenerating populations as indicated by the presence or absence of Stage IV (young mature) individuals. PCA axis 1 represents a contrast between juvenile and mature trees. Its insensitivity to grazing variables could be a reflection of the spatially and temporally erratic nature of rainfall in the study regions, resulting in recruitment events unrelated to grazing variables. PCA axis 3 explains 13.4 percent of the data; its insensitivity to grazing is presumably due to factors not measured in this study.

DISCUSSION

The method used by Crisp and Lange (1976) and Crisp (1978) to estimate plant age by finding a relationship between plant dimensions and age were refined in this study, and shown to be applicable to locations with similar characteristics to the original study region. Such a relationship may have more widespread use with other species that do not yield annual growth rings in arid environments where rainfall and growth periods are erratic. The 'Crisp method' of ageing *Acacia aneura* trees was shown to be uncomplicated, repeatable in space and time, and non-sacrificial.

The results of the study of grazing history and regeneration patterns show that sheep and cattle grazing are significant vertebrate herbivores affecting life stage classes (and by inference, regeneration success) of *Acacia aneura* in the chenopod shrublands of South Australia. Grazing by other herbivores (kangaroos, rabbits and horses) appears to be comparatively unimportant. Our data supports previous findings that various woody trees and shrubs seem destined for extinction due to the selective elimination of their seedlings (Crisp and Lange 1976; Lange and Purdie 1976; Fatchen 1978; Lange and Graham 1983). *A. aneura* populations seem likely to become severely threatened unless management regimes in pastoral areas are modified to prevent the decline of their populations.

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REFERENCES

Crisp, M. D. (1978). Demography and survival under grazing of three Australian semi-desert shrubs. *Oikos* 30: 520-528.

Crisp, M. D. and Lange, R. T. (1976). Age structure, distribution and survival under grazing of the arid shrub *Acacia burkitti. Oikos* 27: 86-92.

Everist, S. L. (1971). Continental aspects of shrub distributions, utilisation and potentials: Australia. *In*: 'Wildland Shrubs - Their Biology and Utilisation US Forest Service General Technical Report Int-1', pp. 16-25.

Fatchen, T.J (1978) Change in grazed *Atriplex vesicaria* and *Kochia astrotricha* (Chenopodiaceae) populations 1929-1974. *Trans. R. Soc. S. Aust.* 102(2): 39-42.

Graetz, R. D. (1978). The influence of grazing on the structure of a saltbush (*Atriplex vesicaria* Hew. ex Benth.) population. *Aust. Rangel. J.* 1(2): 117-125.

Hodder, R. M. and W. A. Low (1978). Grazing distribution of free ranging cattle at three sites in the Alice Springs district, central Australia. *Aust. Rangel. J.* 1: 95-105.

Kent, M. and Coker, P. (1992). Vegetation Description and Analysis: A Practical Approach. Belhaven Press, London.

Lange, R. T. and Graham, C.R. (1983). Rabbits and the failure of regeneration in Australian arid zone Acacia. *Aust. J. Ecol.* 8: 377-381.

Lange, R. T. and Purdie, R. W. (1976). Western myall (*Acacia papyrocarpa*), its survival prospects and management needs. *Aust. Rangeland J.* 1: 64-69.

Moore, P. D. (1976). Influence of grazing. *Nature* 262: 6-7.

Ogden, J. (1985). Past, present and future: Studies on the population dynamics of some long-lived trees. *In* 'Studies on Plants Demography: A Festschrift for John L. Harper' (Ed White J.) Harcourt Brace Jovanovich, London. pp. 3-16.

Randell, B. R. (1992). Mulga. A revision of the major species. *J. Adelaide Botanic Gardens* 14: 105-132.

Tiver, F. and Andrew, M. H. (1997). Relative effects of herbivory by sheep, rabbits, goats and kangaroos on recruitment and regeneration of shrubs and trees in eastern South Australia. *J. Applied Ecol.* 34: 903-914.