The effect camels have on the ability of parkinsonia (*Parkinsonia aculeata* L.) to set seed

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Summary In recent years a concerted effort has been made by research organisations to better understand the biology and ecology of the invasive shrub parkinsonia (*Parkinsonia aculeata* L.) and to develop integrated control strategies. Some land managers have also been testing innovative methods. One such example is the use of camels, with a small but increasing number of landholders purchasing them for the purpose of woody weed control in northern Australia. On two properties in the Charters Towers region, a trial was established to quantify whether camels have a detrimental affect on parkinsonia or are potential dispersers. In browsed and unbrowsed paddocks, the level of pod production, size of seedbanks and presence of seed in camel dung were directly compared. Under heavy continuous browsing, pod production per tree averaged less than one in browsed paddocks in comparison to 3801 per tree under unbrowsed conditions. The soil seedbank present under the canopy of trees was similarly reduced, dropping from 207 seeds per square meter in unbrowsed paddocks to one seed per square meter in browsed areas. In terms of dispersal, camels appear to be low risk, with most dung samples containing less than two seeds. These results suggest that the preferential browsing nature of camels could compliment traditional control methods and lead to a reduced seedling recruitment from the depleted soil seedbank. However, further research is warranted to clarify camel diet preferences particularly with regards their potential impact on native shrubs.

Keywords Browse, parkinsonia, dispersal, soil seedbanks.

INTRODUCTION

Browsing by livestock, including sheep, goats and camels has been used to control weeds (March 2000, US Department of Agriculture 2002, Dörges and Heucke 2003). In recent times, camels have been introduced into northern Australia to control prickly acacia (*Acacia nilotica* L.) and parkinsonia (*Parkinsonia aculeata*) (Deveze 2004). In an integrated parkinsonia management program, the primary objective of existing biocontrol agents and browsing animals is to reduce the plant's reproductive potential. If effective this will result in a reduction in the size of the soil seedbank. Consequently, seedling recruitment should be less following the implementation of conventional control methods.

Currently the major biocontrol agent *Penthobruchus germani* (Pic), which is a seed-feeding bruchid released in Australia in 1995, assists in reducing viable parkinsonia seed input into the soil. Seed predation by this insect has been measured at between 80–90% (Lockett *et al*. 1999) and up to 99.68% (Donnelly 1998). The insect is fairly widespread throughout the range of parkinsonia infestations in Queensland and the Northern Territory (Lockett *et al*. 1999, Lukitsch and Wilson 1999), although an egg parasitoid *Uscanna* sp. can reduce the impact *Penthobruchus* has in some areas (van Klinken 2005).

Information on the impact of camels on parkinsonia or other woody weeds is limited. Plant analysis studies on parkinsonia have shown it to have a low leaf fodder value, due to its moderate to high total fibre content levels, and a nitrogen content of 3.68% with no condensed or hydrolysable tannins indicating high digestibility (Hunter and Steward 1993). Despite the low leaf fodder value, parkinsonia is browsed by camels and sheep (Dörges and Heucke 2003, Lepape 1980). Feeding trials by Dörges and Heucke (2003) found camels to browse selectively on the new foliage of plants. Parkinsonia was cultivated as a browse plant for sheep at the Cape Verde Islands (Lepape 1980). Studies have also shown camels to be more efficient than ruminants in extracting protein and energy from poor quality forages (Fowler 1999).

Co-grazing, which is the combination of different grazing animal species, allows a wider selection of vegetation to be preferentially used therefore improving grazing efficiency at the same time as maintaining or improving animal production (Phillips *et al*. 2001, DBIRD 2001, US Department of Agriculture 2002). Studies have shown that cattle preferentially graze 75% grass (US Department of Agriculture 2002) and camels prefer 95% dicotyledons (Dörges and Heucke 2003).

Traditional weed control options can be expensive particularly in terms of labour, chemical and machinery hire. To treat a medium to dense infestations of parkinsonia (2200 plants ha^{-1}), using labour-intensive control methods such as basal bark spraying cost $420 per hectare in 2001 (McKenzie *et al.* 2004), whilst mechanical control options such as blade ploughing and Ellrott ploughing cost $156 and $126 per hectare respectively (McKenzie *et al*. 2004). These techniques, though effective, require follow-up control after recruitment from the soil seedbank and need to be continued until the seedbank has been exhausted.

This paper considers the effect of browsing by camels on parkinsonia pod production and its impact on soil seedbanks. The potential of camels to disperse parkinsonia seeds was also investigated.

MATERIALS AND METHODS

Two properties in the Charters Towers area were selected for the camel browsing experiment. The two landholders purchased camels in 1999 and 1998 respectively, as a tool for managing parkinsonia. At the commencement of the experiment camels had been grazing the experimental sites for one and three-and-a-half years at Site 1 and 2 respectively.

Wambiana (Site 1) is about 75 km south-west of Charters Towers and had two 30 camel herds grazing in rotation on a parkinsonia infestation along the Campaspe River. The site consisted of mature parkinsonia plants throughout the paddock and a grass cover of approximately 1500 kg ha^{-1}. Scartwater (Site 2) is approximately 150 km south-east of Charters Towers and had 60 camels in a continuous grazing regime on a parkinsonia infestation near the Suttor River. The parkinsonia on Site 2 was confined mainly to an area that is inundated most years and had very limited grass at the time of assessment.

Treatments at each site included a control (no camel browsing) and a camel-browsed plot. Control plots for both sites had no history of camel browsing and were located in paddocks directly adjacent to the browsed areas. A camel-proof fence separated the treatments and they were similar in soil type and density of parkinsonia.

All data was collected in December 2002 to allow the parkinsonia pods to mature but prior to senescing. This enabled accurate pod counts on trees to be undertaken and soil seedbanks to be measured prior to replenishment from new season seed production.

Sampling method Fifteen isolated, seed-bearing, mature trees were selected for each treatment at each site. Trees without touching canopies were chosen so that seed from neighbouring plants would not confound seed collection data from underneath the drip zone of the sampled trees (J. McKenzie and A. Grice unpublished data).

Plant parameters Basal diameter at 20 cm above the ground, height in cm, canopy dimensions in two directions and percentage leaf cover were recorded for each plant. Seed pods were collected from each tree and counted.

Soil seedbank Previous studies have found that ninety-eight percent of the soil seedbank of parkinsonia is located within the drip zone of an adult tree (J. McKenzie and A. Grice unpublished data). Consequently, in this study the drip zone of the plant was used for determining the parkinsonia soil seedbank. The canopy circumferences of each plant was scribed on to the ground surface, and divided into quarters using the plant's stem as the centre. Fifteen cores were randomly collected from each quarter and then bulked. Each core was 5 cm diameter by 5 cm deep. The bulked sixty cores were later sieved though a 2 mm sieve to retrieve parkinsonia seed.

Faecal disposal Fifteen discrete fresh (green in colour, not grey) camel faeces were collected within the browsed areas at both sites to determine the presence or absence of seeds. Faecal extracted seed underwent germination and viability testing. At the time of collection, camels had access to mostly mature pods.

Seed viability test Once recovered, seeds were counted, and damaged seed recorded and removed. The remaining intact seeds were placed in Petri dishes containing a Whatman™ No.4 filter paper and moistened with a systemic fungicide Fongarid™ at 1 g L^{-1} distilled water. The Petri dishes were placed in a germination cabinet set at a diurnal temperature of 25 to 35 ± 1°C and moistened daily with the fungicide mix. Seeds were considered germinated when the radicle extended at least 1 mm beyond the seed coat. Germinated seeds were counted and removed daily for seven days. At this time the seed coats of any remaining seed were scarified with a scalpel to break dormancy. These seeds were then placed back in the germination cabinets for a further seven days with any germinated seed recorded and removed daily.

Statistical analysis Plant cross-sectional area (the basal area at 20 cm height), pod production and viable soil seedbank for browsed and control plots were analysed using the two-sample t test for each site.

RESULTS

Rainfall for the two previous years (2001 and 2002) for this area was 49 and 52 percent of the average.

Based on cross sectional area plants studied were similar in size irrespective of treatment or site, averaging 66.1 (±32.5 SEM) cm^2. Throughout the trial camels were observed feeding on fresh growth including flowers, young pods and leaves. This lead to parkinsonia foliage being reduced by 66% and 77% in browsed plots at Sites 1 and 2 respectively, when compared to the non-browsed controls (see Figure 1).

Browsed plants at both sites contained significantly less seedpods than unbrowsed plants. At Site 1, browsed plants produced a mean of 48.8 ± (25.3 SEM) pods per plant in comparison to unbrowsed with a mean of 2842.5 ± (623.5 SEM) pods per plant (t = −4.476 df = 14, P = 0.001). At Site 2, under continuous browsing, the mean number of pods per plant was 0.2 ± (0.2 SEM) compared to unbrowsed plants with a mean of 3801.7 ± (1277.3 SEM) (t = −2.976, df = 10, P = 0.014) (see Figure 2).

Site 1 had no significant differences in viable soil seedbanks between treatments (t = −1.878, df = 28, P = 0.071). However, at Site 2 there were vast differences, with the seedbank in the unbrowsed plot 46 times higher than the browsed area.

Camel dung was found to contain small quantities of viable parkinsonia seed. For Site 1, seeds per dung averaged 1.8 ± (0.9 SEM), ranging from 0 to 11 seeds per dung, whilst Site 2 had on average 0.3 ± (0.1 SEM) seeds per dung, ranging from 0 to 1.

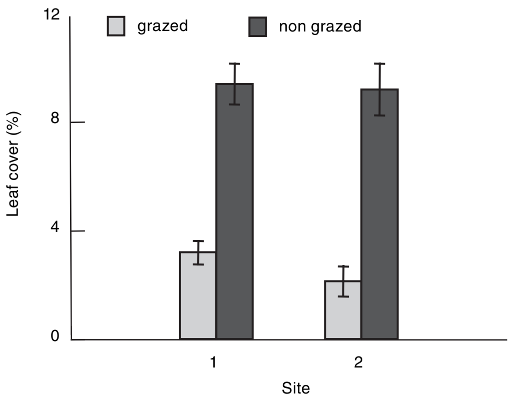

Figure 1. Mean percentage leaf cover of parkinsonia plants growing at two sites (1 = Wambiana and 2 = Scartwater) following browsing by camels. Vertical bars indicate the LSD at P <0.05.

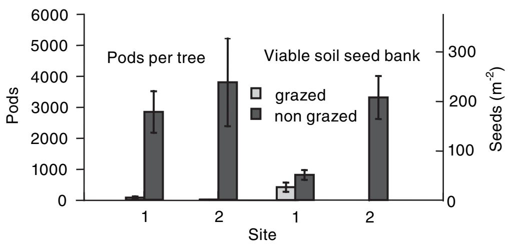

Figure 2. Mean pods per parkinsonia plant and viable soil seedbank under individual parkinsonia plants growing at two sites (1 = Wambiana and 2 = Scartwater) following browsing by camels. Vertical bars indicate the LSD at P <0.05.

DISCUSSION

This experiment demonstrated that camels have the ability to reduce seed production, leading to a net decline in the soil seedbank over time. Browsing of fresh growth and flowers by camels could have attributed to this significant reduction. Parkinsonia pods did not appear to be deliberately eaten by the camels but were consumed along with the palatable leaf material or when limited preferential food was present such as in Site 2. In another experiment where camels were fed parkinsonia seed it was found that seed was only eaten incidentally with other desirable attractants such as molasses, salt and grain (J. McKenzie unpublished data).

Reduced time frame could explain why Site 1 had not achieved a significant reduction in the viable soil seedbank compared to Site 2. Camels were only introduced to the paddock at Site 1 one year prior to the commencement of the experiment, compared to three-and-a-half years for the paddock studied in Site 2.

Approximately 15% of seeds consumed remain viable after digestion by camels (J. McKenzie unpublished data). When confined to an infested area the threat of seed spread by camels is inconsequential compared to the benefits of both less seeds being produced and a low seed viability of consumed seeds by camels. However in areas where camels are not confined, they could act as vectors for dispersal.

During the trial impacts from camels were also observed on native flora. The impacts of camels to off-target species should also be considered when contemplating the use of camels as a tool for parkinsonia management. Under some grazing regimes camels have the potential to contribute to a decline in preferred food plants (Dörges and Heucke 2003). At Site 2 observations suggested that Prickly pine (*Bursaria incana* Lindl.) and Emu apple (*Owenia acidula* F.Muell. ex Benth.) were heavily grazed while other species such as white wood (*Atalaya hemiglauca* F.Muell.) and Bendee (*Acacia catenulata* C.White) were grazed to a lesser level. Dörges and Heucke (2003) found that white wood had a palatability rating similar to parkinsonia.

CONCLUSION

In conclusion, camels could play a role as part of an integrated management program. The ability of camels to reduce the quantity of seed entering the soil seedbank, should result in landholders having less seedling regrowth to treat once they control initial infestations using conventional techniques (such as machinery and herbicides). However, care is required to manage herd numbers and to ensure that off-target damage and overgrazing due to dietary overlap of species is minimised.

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