The germination, passage and viability of *Desmanthus virgatus* (L.) Willenow seed through sheep and its implication for dispersal in tropical rangelands

Chris Gardiner[1] , Carole Wright[2] and Michele Coventry[3]

[1] School of Veterinary and Biomedical Sciences, James Cook University, Townsville Qld. 4811 Australia. Email christopher.gardiner@jcu.edu.au
[2] DAFF, PO Box 1054 Mareeba, Qld. 4880 Australia. Email carole.wright@deedi.qld.gov.au
[3] Agrimix Pty.Ltd. 19 Chapman Place, Eagle Farm Qld. 4009 Australia. Email michele@thecoventrys.com

Abstract

Vast areas of semi-arid clay soil regions of northern Australia have no commercially available or adapted sown pasture legume. Livestock in the region suffer an annual prolonged protein drought. An adapted pasture legume could enhance the productivity and sustainability of the regions pastures and livestock. Agronomic trials have found that of all legumes tested to date *Desmanthus* species are the best survivors in such environments. *Desmanthus* is a native of the Americas, is palatable, productive and has good protein content. The rangeland grazing communities of Queensland appreciate the value that an adapted pasture legume would provide and are keen to improve the productivity of both their livestock and their native and introduced grass pastures. The very extensive nature of the region however poses problems in sowing and establishing a new pasture species given a lack of a sown pasture culture and broad-acre farming equipment in the region and the potential expense of sowing such vast rangelands. Ruminant livestock are known to be capable of dispersing hard-seeded leguminous seeds through their faeces, therefore faecal seeding may be one possible mechanism of establishing *Desmanthus* into these landscapes. This paper explores the scarification, germination, passage and viability of *Desmanthus* seed through sheep. It was found that scarification significantly enhances germination to 79% and 9.1% of seed fed to sheep passes through the digestive tract within 48 hours and a proportion of which remains viable and capable of germinating. We consider faecal seeding as a means of establishing *Desmanthus* into suitable rangelands.

Key Words

Faecal seed dispersal, legume seeds, germination, ruminants

Introduction

Vast areas of semi-arid clay soil rangeland regions of northern Australia, e.g. the Mitchell Grass Downs Bioregion, have no commercially available or adapted sown pasture legume. Low livestock productivity in northern Australia is largely due to low protein content and low digestibility of the diet during the dry season (Poppi and McLennan 2010). An adapted pasture legume could ameliorate this problem and enhance the productivity and sustainability of the regions grazing sector. Gardiner et al. (2004) found that of all the legume species tested to date a number of *Desmanthus* spp. are the best survivors in the above mentioned region. Bell (2009) discussed the concept of the marginal value of feed. As *Desmanthus* is well adapted to the region and has good protein content, we would expect it to have a very high marginal value of feed given that the native grasses are often in short supply and are for much of the year of poor quality. *Desmanthus* spp. are prostrate to erect, herbaceous to suffruticose Mimosaceae legumes native to the Americas (Luckow 1993). Agrimix (n.d); Cook et al. (2005) describe them as tolerant of heavy grazing, persistent in low rainfall environments, nutritious and tolerant of alkaline and clay soils.

The rangeland grazing communities of northern Australia appreciate the value that an adapted pasture legume would provide and are keen to improve the productivity of their livestock and sustainability of both their native and introduced grass pastures in a similar manner that the *Stylosanthes* spp. have delivered to light textured soil regions of northern Australia. The stylo’s regularly enhance cattle weight gains by some 30–60 kg/head/annum resulting in improved breeder, weaner performance and turnoff weights (Coates et al. 1997). Rangel and Gardiner (2009) demonstrated the benefit of providing a legume to sheep fed a diet of Mitchell grass hay as manifested in higher feed intake, reduced weight loss and improved wool growth.

The very extensive nature of the grazing properties across northern Australia poses problems for sowing and establishing a new pasture species. Such problems include a lack of a sown pasture culture, the scarcity of broad-acre farming equipment in the region and the potential expense of sowing such immense rangelands. Leguminous species with hard seeds are known to survive digestion and be dispersed by ruminants and the seeds themselves also provide valuable nutrition because of their high protein content (Russi et al. 1992).

Simao Neto and Jones (1987) found that hard seeds were largely resistant to digestion. Using Switch grass (*Panicum virgatum*) Occumpaugh et al. (1996) demonstrated significant advantages of faecal seeding over conventional broadcast seeding in terms of seedling emergence, establishment and growth. Armke and Scott (1999) found that 75% of seeds of *D. illinoenis* (Illinois bundleflower) fed to cattle were recovered in faeces and had a high germination rate. They suggest that *D. illinoensis* is a potential candidate for faecal seeding.

This paper examines;

- the effects of hot water seed scarification on *Desmanthus* germination percentage
- the effects of digestion on germination percentage
- the effects of scarification pre and post digestion on seed germination
- passage time of *D. virgatus* seeds through sheep

We consider and discuss faecal seeding as a mechanism of establishing *Desmanthus* into suitable rangeland environments.

Methods

Twelve merino wethers with a mean live weight of 24.25 kg were housed in individual metabolism cages at the School of Veterinary and Biomedical Sciences, James Cook University, Townsville, Australia. The sheep were acclimatised to the housing and had an *ad libitum* high quality diet of Lucerne pellets, Ridley Pty. Ltd. custom sheep pellets (14.5% CP) at 500 g each plus lucerne hay and water adlib. Sheep were weighed and paired up on similar weights and then randomly assigned to either being fed an untreated ("hard") seed treatment or a scarified ("soft") seed treatment. The seed scarification treatment involved pouring boiling water over the seeds, allowing them to soak in the hot water for 1 minute, draining and then sun drying.

On day 1 six sheep were each offered 100 g of the control untreated (hard) *D. virgatus* seed and the other six sheep were offered 100 g of scarified (soft) *D. virgatus* seed. Faecal deposits were collected each day from individual sheep for three days. The faecal pellets were air dried on trays and then a 50% by weight subsample of each sheep's daily faecal pellets was then rehydrated in a bucket of water and emasculated by hand and washed through a set of sieves ranging in size from 4 mm to 0.5 mm. The resulting fine faecal pieces and seeds were then sundried and put through a variable speed fan winnower which separated the seeds from the faecal matter. The total seeds recovered from each sample were weighed and counted.

Germination test

Seed germination tests were carried out on *Desmanthus* seeds before ingestion and post digestion and with both pre ingestion and post digestion treatments being applied as outlined below. Seeds extracted from day 2 faecal pellets were used in treatments 3- 6.

Germination treatments investigated were:

1. Untreated seeds (control) (not scarified = "Hard" seeds), not fed to sheep
2. Scarified seeds (hot water scarified = "Soft" seeds), not fed to sheep
3. Untreated seeds recovered from faecal pellets ("Hard" seeds fed to sheep)
4. Scarified seeds recovered from faecal pellets ("Soft" seeds fed to sheep)
5. Untreated seeds recovered from faecal pellets and hot water scarified (post digestion treatment)
6. Scarified seeds recovered from faecal pellets and hot water scarified (post digestion treatment)

The germination experiment was laid out as a completely randomised design with 3 replicates of each of the above 6 treatments. One hundred seeds were used in each 9 cm Petri dish containing two sheets of Whatman filter papers no. 1001090 which were kept moist and every 24 hours counts of seeds germinated were recorded. The mean ambient temperature of the germination laboratory was 32.5^{o}C.

The number of seeds recovered each day was analysed using a generalised linear model (GLM) assuming a poisson distribution, while the number of seeds which germinated after 7 days was analysed using a GLM assuming a binomial distribution.

Results

Passage of seeds

Significantly more seeds were recovered in the sheep's faecal pellets on day 2 (P=0.004) compared to day 1 and 3. However, no significant difference was found between the number of Soft (scarified) and Hard (untreated) seeds recovered. Given the higher recovery of seeds on day 2, these seeds have been used in the germination trial to investigate seed viability after passing through the sheep guts.

Germination

The hot-water scarified treatment (Treatment 2) produced 79% germination compared to the untreated control (Treatment 1) seeds which had a significantly lower germination of 23% (Figure 1). Overall the digestion of seeds through the sheep guts results in significantly lower germination (P<0.001) compared to undigested seeds (means of 22% and 51% respectively). Digested hard and soft seeds exhibited the lowest levels of germination of all treatments, 5% and 3% respectively. However, the post-scarification of digested seeds significantly increased germination from an average 4% to an average 56% (P<0.001). This increase in germination is evident for both hard and soft digested seeds; 5% germination to 57% for hard seeds, and 3% to 56% for soft seeds. The number of seeds recovered from the faeces was 9.1% of the seeds fed.

The following graph shows the predicted germination percentages for each of the six treatments with the error bars representing +/- one standard error. The letters above the graph identify significant differences based on Tukey's corrected multiple comparison procedure.

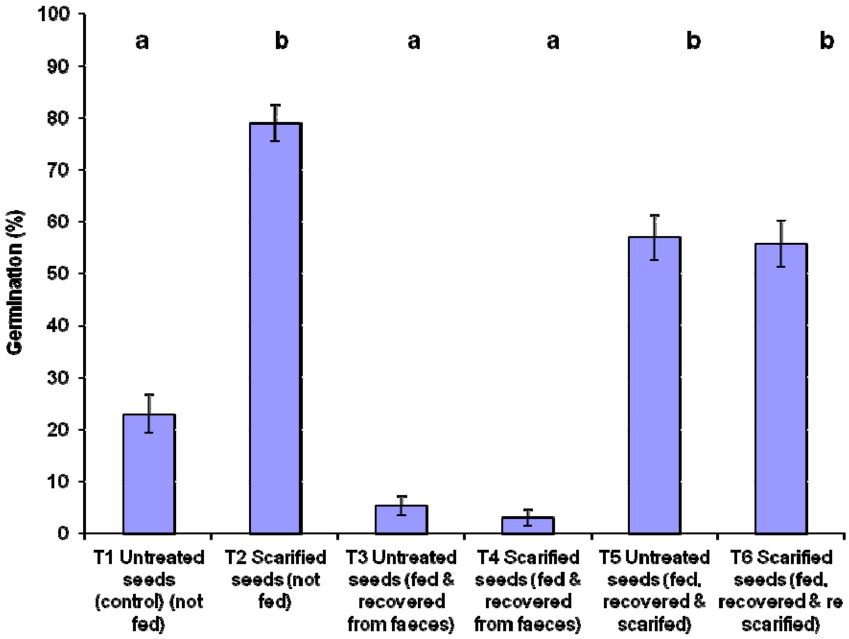

Figure 1. Germination percentage of six seed treatments pre and post digestion

Discussion and conclusion

The *Desmanthus* seeds were readily consumed by the sheep which suggests the same is likely to occur in the field or if fed with dry season supplementary feeds. *Desmanthus* has a high degree of hard-seedness and hot water scarification is an effective way of scarifying the seed to improve germination. Our 79% germination following scarification with hot water concurs with findings of Hopkinson and English (2004). The bulk of our *Desmanthus* seed passed through the sheep in 2 days and this is a similar result as for other legumes as reported by Simao Neto and Jones (1987). The post digestion hot water scarification treatment of the recovered digested seed proved to be a simple method of determining that a high percentage of the recovered seeds were indeed still viable. The results of using this technique suggest that almost the entire naturally soft seed portion of the seed fed was digested leaving only harder seeds to pass through the gut. Our results show that the germination of seeds post digestion is low (about 4%) but the seeds are still very viable as when additional scarification was applied post digestion, the germination rose to nearly 60%. The results also suggest that the seed that was scarified prior to feeding was surprisingly still quite resistant to digestion as 56% germinated when additional scarification was applied post digestion. Further investigations to look at the effects of a longer time in the rumen i.e. 3 or 4 days versus 2 days, as used in this study, may for example show that some of the hard seeds soften up and may therefore be digested or just softened/digested enough to enhance germination. We suggest, but it remains to be tested, that with time the hard seeds sitting in the faecal pellet in the paddock will be slowly softened by the environment and will eventually germinate. Armke and Scott (1999) put forward that seeds delivered in dungpats should benefit from the microsite's high organic matter, high moisture content, short-term reduction in competition with pre-existing vegetation and short term grazing avoidance. The high recovery (75%) of *D. illinoenis* seeds reported by Armke and Scott (1999) suggests cattle may be much better faecal seeders than sheep as we found only 9.1% of *D. virgatus* seeds fed was recovered through sheep. As to the question of whether to feed hard seed (not scarified) to sheep or to feed them scarified seed, our results suggest that there is no significant difference in the germination percentage post digestion. Coleman Livestock Feeds Pty. Ltd. (David Coleman, pers com) report regular requests from northern Australian graziers for stylo seeds to be added to their companies' dry season supplement preparations for cattle as a mechanism of faecal seeding stylos across the grazed landscapes. There appears to be no research as to the success of this local practice but the demand for it suggests graziers see it as an option for pasture legume establishment.

If the results of Ocumpaugh et al. (1996) using a grass can be replicated but with *Desmanthus* i.e. that faecal seeding significantly enhanced seedling emergence, establishment and growth over broadcast seeding then there may be a real role for faecal seeding of *Desmanthus*. However, additional studies will be required to explore the actual germination and establishment of *Desmanthus* seeds from within faecal pellets and pats of both sheep and cattle under laboratory and field conditions versus other planting methods. Further investigations are also needed as to how they are distributed across paddocks and the time (perhaps years) it may take to obtain a good legume content in a faecal seeded paddock versus other establishment methods, and the economics of each establishment method also requires investigation.

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