Journal of Animal &Plant Sciences, 2016. Vol.28, Issue 3: 4456-4456
Publication date 1/05/2016, **http://www.m.elewa.org/JAPS***; ISSN 2071-7024*

Increased browsing pressure on a woody encroacher (*Dichrostachys cinerea*) treated with molasses: a pilot study

C. Esterhuizen and W.J. Myburgh
Department of Nature Conservation, Tshwane University of Technology, Private Bag X680, Pretoria 0001, South Africa
Correspondence should be addressed to W. J. Myburgh; myburghwj@tut.ac.za

Keywords: bush encroachment, molasses, utilization pressure, *Dichrostachys cinerea*

1 ABSTRACT

Bush encroachment is a global problem, which decreases the herbaceous productivity and the carrying capacity of an area. The loss of grassland and savannah habitat to encroaching woody species is a major concern of wildlife conservationists and conservation agencies around the world. The objective of this study was to investigate differences in utilization pressure on the woody species encroacher *Dichrostachys cinerea* (Sickle bush) by browsers, between molasses treated and non-treated individuals, on Madikwe Game Reserve (MGR). A total of 200 *Dichrostachys cinerea* individuals were studied in an area of 2 147 ha (2.36%) of the reserve. One hundred woody individuals were treated with molasses (an energy supplement from sugarcane that has been proven to increase utilization of low quality forages) and the remaining one hundred individuals served as the control and were not exposed to the molasses treatment. The results of the Cramer's V statistical tests indicated that there were significant differences in utilization between the treated and non-treated woody individuals. It is therefore confirmed that molasses application will increase utilization pressure by browsers, particularly elephants.

2 INTRODUCTION

Bush encroachment affects the agricultural productivity and biodiversity of between ten and twenty million hectares of South Africa (Ward, 2005). The causes of bush encroachment are multifaceted and therefore the management recommendations must be site specific. According to research done by Smit *et al.* (2001), bush encroachment had decreased the potential grazing capacity by as much as 331%, 149% and 58% in the Molopo Thornveld, the Mixed Vaalbos Thornveld and the Eastern Grass Bushveld of South Africa respectively. Smaller natural areas require greater ecological management inputs to maintain the long-term ecological integrity of the landscape and successfully achieve management goals and objectives. The suppressive effect of bush encroachment is a major reason why clearing or thinning of woody plants is considered as a management option (Donaldson, 1973; Van Niekerk and Kotze, 1977; Jacoby *et al.*, 1982; Gammon, 1984; Moore *et al.*, 1985; Heitschmidt *et al.*, 1986; Moore and Odendaal, 1987; Scholes, 1987; Smit, 2005). Madikwe Game Reserve (MGR) is a prime example of a recently designated protected area that is plagued with bush encroachment of primarily *Dichrostachys cinerea* (Sickle bush) (Figure 1), but also *Vachellia* and *Senegalia* species (Figure 2), due to its historical land use as stock farms.

Journal of Animal &Plant Sciences, 2016. Vol.28, Issue 3: 4456-4456
Publication date 1/05/2016, **http://www.m.elewa.org/JAPS***; ISSN 2071-7024*

Figure 1: *Dichrostachys cinerea* (Sickle bush)

Figure 2: *Vachellia mellifera* (Black thorn)

MGR requires a strategy or a combination of strategies to manage or control woody plant proliferation in the most cost effective way to decrease the negative effects on herbaceous productivity. The slow progress and low success rate of the current bush clearing project on the MGR necessitated the need to investigate other possibilities. A completely different approach was therefore researched and considered. Research has shown that molasses, which is a natural supplement, will prevent weight losses of lambs fed with poor quality forages in winter conditions of north east Turkey (Unal *et al*., 2005). This study proved that dry and organic matter intake supplemented with molasses increased significantly and digestibility was improved. Using a molasses supplement did not prevent weight losses in lambs fed with poor quality forage, but decreased it, concluding that molasses in lambs fed with poor quality forage may decrease body weight losses and prevent sporadic mortalities in winter conditions of north east Turkey (Unal *et al*., 2005). Molasses is a natural supplement that improves nutrition and the animals can better utilize crop residues if the requirements of the rumen bacteria are balanced by supplying deficient nutrients. One of the most efficient ways of increasing utilization of crop residues is supplementation of nitrogen (N) and energy in the form of molasses mineral blocks (Unal *et al*., 2005). Molasses has been used in large and small ruminants as supplementation to improve intake and digestibility of crop residue especially in developing countries (Srinivas and Gupta, 1997; Verma et *al*., 1998; Vu *et al*., 1999; De and Singh, 2003; Unal *et al*., 2005). On average, molasses supplementation increased forage dry matter intake by 9%, compared to reported studies in cattle (Unal *et al*., 2005). Toppo *et al.* (1997) reported a 30% increase and De and Singh (2003) reported a 23% increase in forage dry matter intake with molasses supplementation in cattle fed on straw. Above mentioned studies primarily focused on the use of molasses on herbaceous plants and crop residues and no evidence could be found that molasses has been applied to any woody species in an attempt to increase utilization of a target species, prior to this study. It is therefore concluded that molasses is a useful tool to improve utilization of low quality forage (Unal *et al*., 2005) and therefore could potentially be a very productive biological bush control agent by stimulating and increasing utilization of *D. cinerea* by treating this woody species with molasses.

3 STUDY AREA

The MGR is presently 62 000 hectares in extent and is located in the northern region of the North West Province of South Africa (Figure 3). It is bounded in the north by the international border with neighbouring Botswana, to the west by the Zeerust – Gaborone road (R49), to the

Journal of Animal &Plant Sciences, 2016. Vol.28, Issue 3: 4456-4456
Publication date 1/05/2016, **http://www.m.elewa.org/JAPS***; ISSN 2071-7024*

east by the Marico River and in the south by the Dwarsberg range of hills. The Molatedi Dam, with a surface area of 3 000 ha, is located in the south east of the reserve at a point where the Marico River flows northwards through the Dwarsberg. This reservoir and the adjacent land represents a further 12 000 ha to be incorporated into the reserve in the future. The reserve is approximately 340 kilometres or three hours drive by road from the large metropolitan areas of Johannesburg and Pretoria and only 25 kilometres from Gaborone, the capital of Botswana (Davies, 1997).

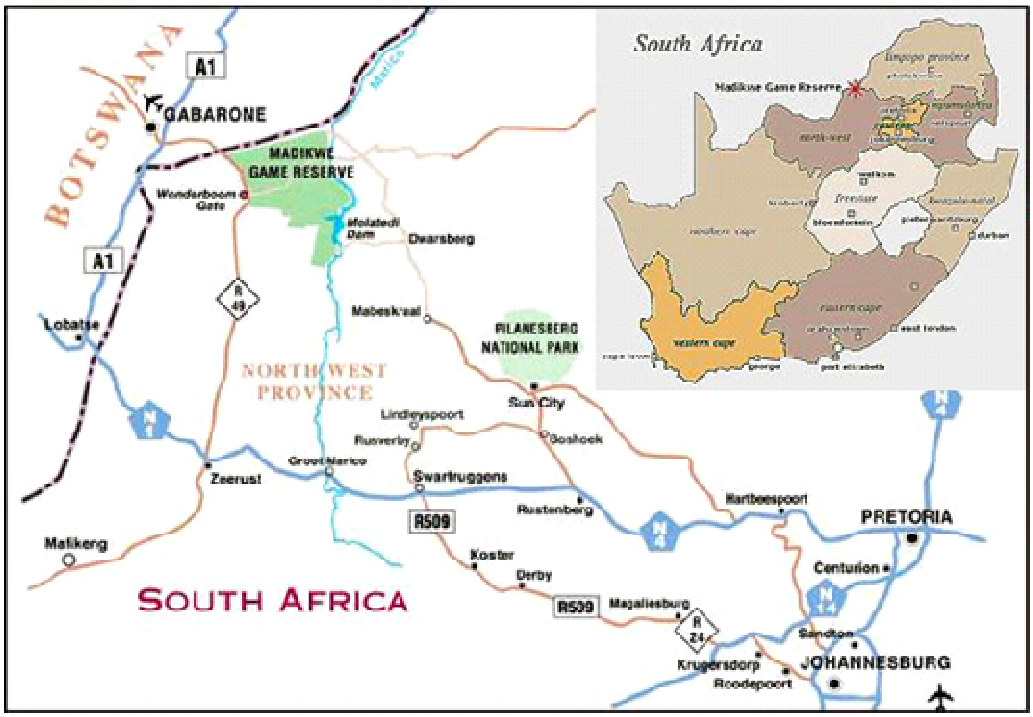

Figure 3: Location of the Madikwe Game Reserve in relation to the Gauteng Province within South Africa

4 METHODS

4.1 Rationale: The current bush control program implemented on MGR is not effective in the control of *Dichrostachys cinerea*, which is considered the primary encroaching species on the reserve. This study focuses on the use of molasses sprayed on *D. cinerea* in an attempt to increase utilization pressure by browsers, particularly elephant, to an extent that this approach will effectively contribute towards the current bush encroachment control program of MGR. This is a pilot study, in order to test the effect of spraying molasses on *D. cinerea* individuals to determine whether the use of molasses would increase utilization of this woody species by browsers.

4.2 Stratification and demarcation of sample areas: Encroached areas were stratified and mapped as potential sample areas, using black and white aerial photographs (Scale - 1:10 000). Using the aerial photograph, a sample area was demarcated. The sample sites within the sample area and woody individuals within these sites, used for the survey were selectively chosen using the following criteria:

- Practical, close and easy enough to access on a daily basis from a monitoring point of view;
- Included *D. cinerea* that were previously exposed to chemical treatments;
- Included *D. cinerea* that were previously exposed to fires and burning programs;

Journal of Animal &Plant Sciences, 2016. Vol.28, Issue 3: 4456-4456
Publication date 1/05/2016, **http://www.m.elewa.org/JAPS***; ISSN 2071-7024*

- Included *D. cinerea* that were previously exposed to manual methods of removal, yet unsuccessful, as was the case for the chemical and fire treatments;
- Representative of both areas close to and further removed from water sources;
- Representative of both areas close to and further away from known feeding paths/game paths;
- Contained *D. cinerea* that varied in height and structure, multi- or single stemmed and;
- Sample sites were representative of both red (sandy) and black (clay) soils.

4.3 Placement of sample sites: *D. cinerea* individuals: The sample included 100 sample sites. These sample sites, were located in the north-eastern section of the reserve and were spread throughout the sample area, covering an area of 2 147 ha (2.36%) of MGR. Each sample site consisted of a treatment and control woody plant that was on average located three meters apart. Only *D. cinerea* individuals were treated with molasses to determine if browsers would be attracted to these treated individual plants.

4.4 Number of samples: A total of 200 *D. cinerea* individuals (100 individuals served as treatment sites and 100 individuals served as control sites), were sampled in the demarcated sample area during 2010.

4.5 Field work and data recording: The survey was conducted over a 12 month period, which included all four seasons. The same two observers applied the molasses and recorded data throughout the study period, limiting observer bias.

4.6 The treatment: Molasses mixture: The liquid molasses was diluted with 50% water to thin the substance for better application. The medium, liquid molasses is a similar consistency to that of tar and if not diluted would not be able to be applied by means of a pressure pump. There have been no previous studies of this nature to be used as a guideline for molasses concentrations. A departure point was a 50% dilution, but further studies in future could refine this ratio and determine if a lower concentration would be equally effective.

4.7 Application and monitoring equipment: The application equipment consisted of a 210 L plastic container as a reservoir. This container was mounted onto a stable structure on the back of a pickup and connected to a 220 V pressure pump. A 6 mm diameter hosepipe of twenty meters was connected to the pressure pump outlet and a controllable spray nozzle was connected to the delivery point of the hosepipe. The pressure pump was powered by a 4.5 KVA diesel generator and mounted separately on the vehicle. Three additional 25 l drums filled with molasses, already diluted with 50% water, a 25 l drum of water, a funnel for easy filling of the 210 l container and additional diesel accompanied the equipment. Additional to the application equipment, a clipboard with field survey forms, camera, GPS and markers (spray painted rocks) were used during the fieldwork phase of the study.

4.8 Data recording at each sample site: GPS co-ordinates were recorded of both the treatment and control sites. These sites were marked with a spray painted rock and photographs of both the treatment and control sites were taken. Additional information recorded at each site, included:

- Impact monitoring (degree of impact on *D. cinerea* by twig browsing, branch breaking and/or uprooting);
- Distance from a game path or game path's;
- Distance from a water source;
- Height of *D. cinerea* individuals;
- Multi or single stemmed individuals;
- Colour of soil (red - sandy soils and black - clay soils); and
- Animal species that influenced the woody component (photos, impact signs on plant).

After recording all relevant information, the sample sites were sprayed with the molasses mixture. *Dichrostachys cinerea* individuals were sprayed with approximately four litres of

Journal of Animal &Plant Sciences, 2016. Vol.28, Issue 3: 4456-4456
Publication date 1/05/2016, **http://www.m.elewa.org/JAPS***; ISSN 2071-7024*

molasses during application. A total of 400 litres of molasses were required to treat 100 *D. cinerea* individuals. After locating and marking the sites, treatment started immediately and was repeated every 3rd month starting in September 2010. The impact was however recorded on a monthly basis using the following categories: Category 1: No impact (0%), Category 2: Slight to moderate impact (1-75% of individuals impacted on), Category 3: Severe impact (76 -100%). The *D. cinerea* individuals were also re-photographed in order to photographically compare the extent of the impact as the study progressed. The monitoring was done over a twelve month period and included all four seasons, spring (early wet season), summer (late wet season), autumn (early dry season) and winter (late dry season).

4.9 Data analysis: The treated and control sites were classified into three categories depending on the degree of impact, Category 1: No impact (0% impact), Category 2: Slight to moderate impact (1-75% of individuals impacted on), Category 3: Severe impact (76-100%). The data set was imported into the SAS System, which is the statistical program used to conduct the Cramér's V tests (Everitt, 1998). Cramér's V was chosen as the appropriate test of association or homogeneity due to its insensitivity to zeros in the data set. Cramér's V is a measure of association between two nominal variables, giving a value between 0 and +1 (inclusive). It is based on Pearson's chi-squared statistic.

5 RESULTS AND DISCUSSION

In the treated sites, 10% of *D. cinerea* individuals had no impact, 44% had slight to moderate impact and 46% of the treated *D. cinerea* individuals had severe impact or were completely destroyed by browsers, particularly elephants. The results of the 100 control sites indicated that 87% of *D. cinerea* individuals had no impact and 13% individuals had slight impact by browsers. None of the control sites fell into the severely impacted or destroyed category, indicating a significant difference in impact between the control and treated sites ($\Psi = 0.399$, $df = 2$). Browsers do alter the growth form and differentially utilize the treated *D. cinerea* individuals as 90% of the treated sample sites had some form of impact of which 44% were slight to moderate impact, altering the growth form of the *D. cinerea* individuals slightly and 46% of the treated sample sites were severely impacted on or destroyed, altering the growth form of the treated *D. cinerea* individuals severely or completely destroying the plant. The control sites indicated that only 13% of the sites were slightly altered and 87% had no alteration at all (Figure 4). The results of 46% treated *D. cinerea* individuals that fell into the severely impacted on or completely destroyed category indicates that browsers indeed uproot/and or kill treated *D. cinerea* individuals. In the control there were no individuals that fell into the severely impacted on or completely destroyed category indicating that there are significant differences between the treatment and control sites with regards to impact from browsers (Figure 4).The degree of impact by browsers in the different seasons was compared. A clear trend was seen concerning impact on the treated sites (Figure 5) that were more prominent in the late dry season. The impact in the control sites (Figure 6), although very slight, showed the same trend once again reiterating the fact that browsers prefer selecting treated sites in comparison to untreated controls sites. The trend as indicated in Figures 4 and 5 could however be because the treatment and control sites were exposed to the browsers for a longer period by the end of the late dry months than during the initial exposure in the early wet season.

Journal of Animal &Plant Sciences, 2016. Vol.28, Issue 3: 4456-4456
Publication date 1/05/2016, **http://www.m.elewa.org/JAPS***; ISSN 2071-7024*

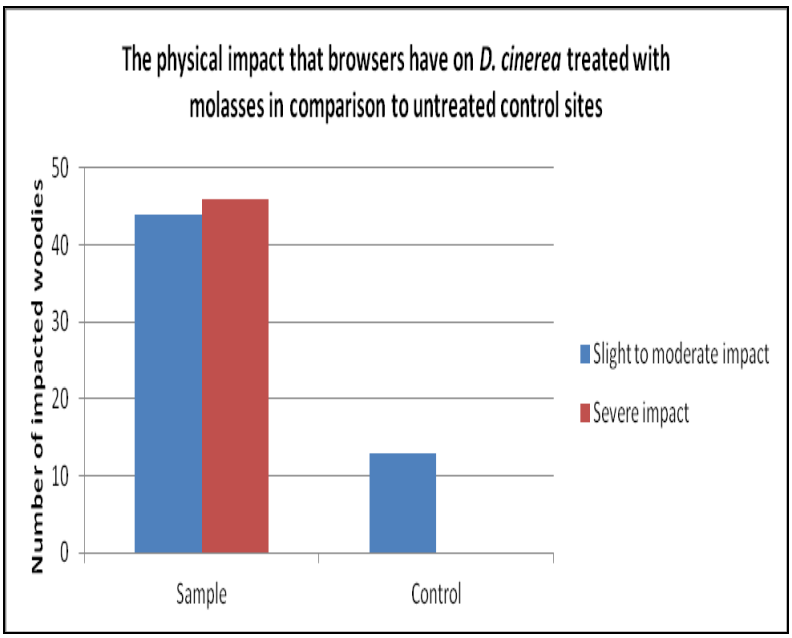

Figure 4: Differences in browser impact between the treated and untreated *D. cinerea* individuals in 2010, MGR, North West Province, South Africa

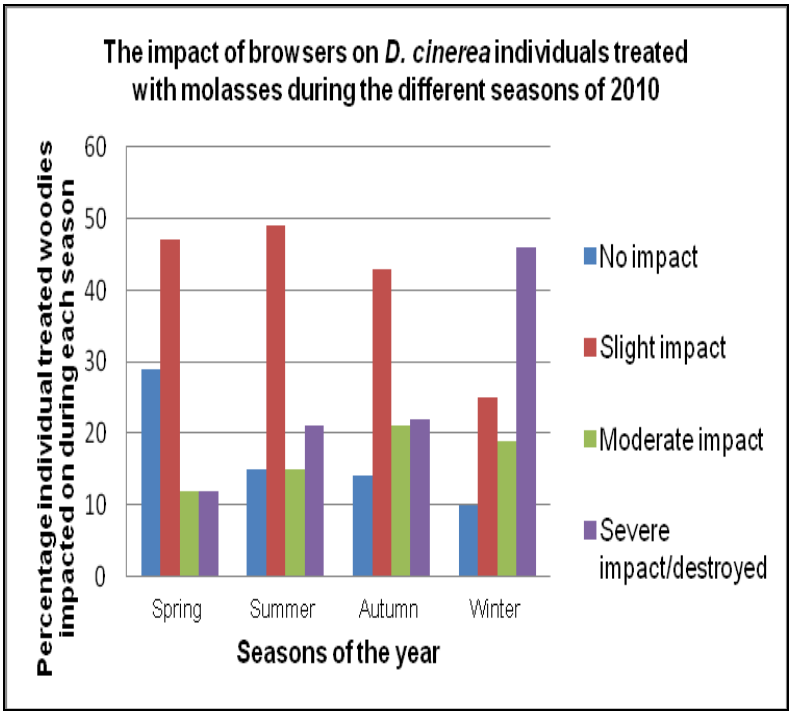

Figure 5: The impact of browsers on molasses treated *D. cinerea* individuals during the different seasons of 2010, MGR, North West Province, South Africa

Journal of Animal &Plant Sciences, 2016. Vol.28, Issue 3: 4456-4456
Publication date 1/05/2016, **http://www.m.elewa.org/JAPS***; ISSN 2071-7024*

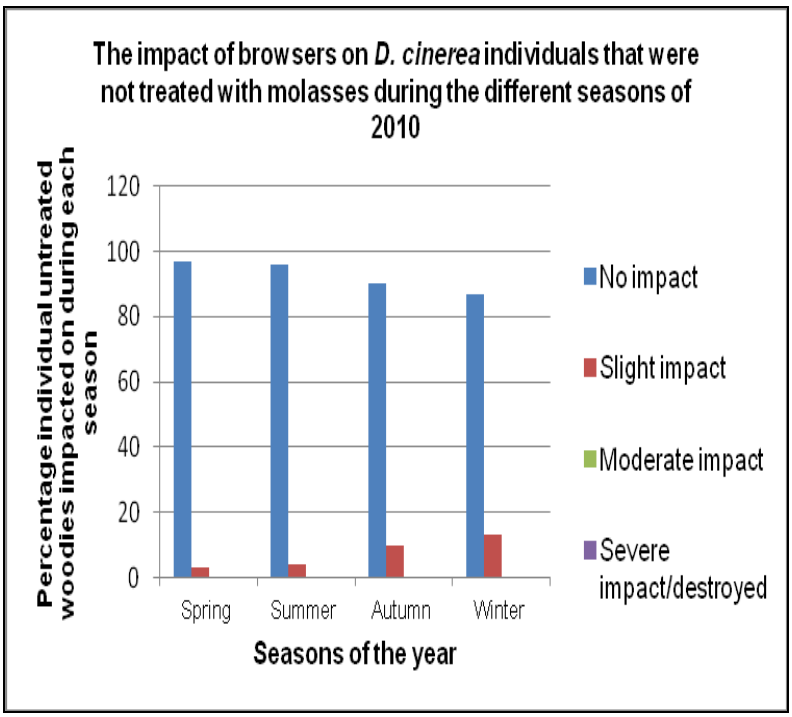

Figure 6: The impact of browsers on *D. cinerea* individuals not treated with molasses during the different seasons of 2010, MGR, North West Province, South Africa

The influence of sample site distance from a game path on browser preference and impact was also investigated. The 100 treated sites included 61 treated *D. cinerea* individuals less than 10 m from a game path and of these 61 treated sites, 6 (9%) had no impact, 28 (46%) had slight to moderate impact and 27 (44%) had severe impact. There were 39 treated *D. cinerea* individuals that were further than 10 m from a game path, of which 4 (10%) had no impact, 16 (41%) had slight to moderate impact and 19 (49%) had severe impact or were completely destroyed (Figure 7). Of the 100 control sites, 61 sites were less than 10 m from a game path, of which 50 (83%) had no impact and 11 (18%) showed slight to moderate impact. There were no individuals recorded in the severely impacted or completely destroyed impact category. Thirty nine control sites were further than 10 m from a game path, of which 37 (95%) had no impact and 2 (5%) had slight to moderate impact, with no impact recorded in the severely impacted on or completely destroyed category (Figure 8). The differences in utilization pressure by browsers between the treated and control sites, especially in the slight to moderate and severely impacted on or destroyed categories (Figures 7 and 8) suggest that, irrespective of distance from a game path, browsers do select treated individuals rather than the untreated control plants. The results in Figure 7 however suggest an increase in utilization pressure by browsers closer to game paths.

The following results were obtained correlating distance from a water source with the degree of utilization of both treated and control sites. Forty five of the 100 treated sites were less than 1 km from water of which 6 (13%) had no impact, 21 (47%) had slight to moderate impact and 18 (40%) had severe impact or were completely destroyed. There were 55 treated sites further than 1 km from water, of which 4 (7%) had no impact, 23 (42%) had slight to moderate impact and 28 (51%) had severe impact or were completely destroyed (Figure 9).

In the control sites, 45 sites were closer than 1 km from a water source and the remaining 55 sites were further than 1 km from the water.

Journal of Animal &Plant Sciences, 2016. Vol.28, Issue 3: 4456-4456
Publication date 1/05/2016, **http://www.m.elewa.org/JAPS***; ISSN 2071-7024*

Utilization impact of the 45 control sites closer than 1 km from water can be summarized as follows: 42 (93%) showed no impact, 3 (7%) showed slight to moderate impact with no impact recorded on the severely impacted on or destroyed category. There were 55 control sites more than 1 km from a water source, of which 45 (82%) had no impact and 10 (18%) had slight to moderate impact. Once again, there were no recordings of impact on the severely impacted on or destroyed category (Figure 10). The results illustrating the influence of distance from a water source for the treated (Figure 9) and control sites (Figure 10) clearly indicate that, irrespective of distance from a water source, browsers do select treated individuals rather than the untreated control plants. Figure 9 however suggests that treated individuals further from a water source were impacted on to a greater extend. This phenomenon positively reinforces the contribution of molasses as biological control agent.

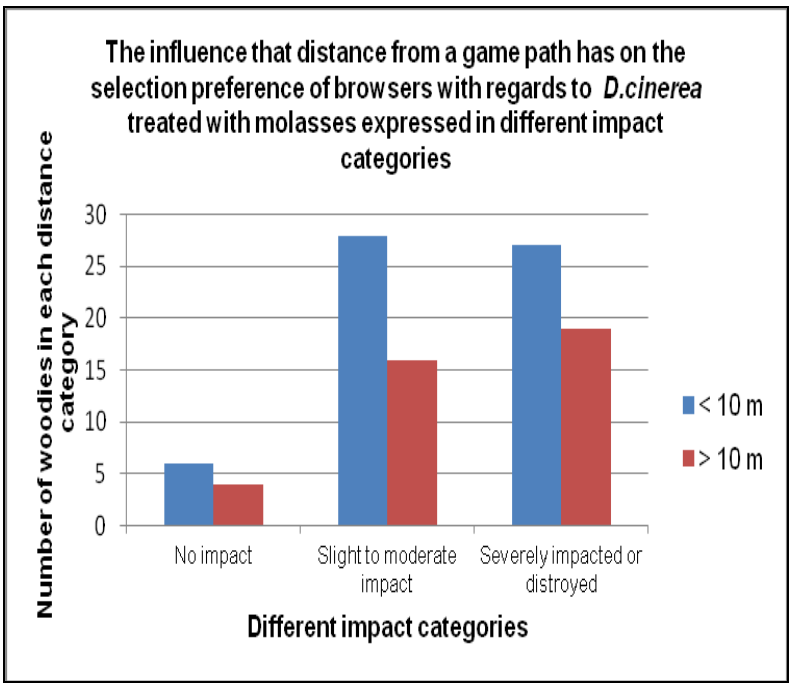

Figure 7: Distance from a game path and the selection preference of browsers for *D. cinerea* treated with molasses on MGR, North West Province, South Africa

Journal of Animal &Plant Sciences, 2016. Vol.28, Issue 3: 4456-4456
Publication date 1/05/2016, **http://www.m.elewa.org/JAPS***; ISSN 2071-7024*

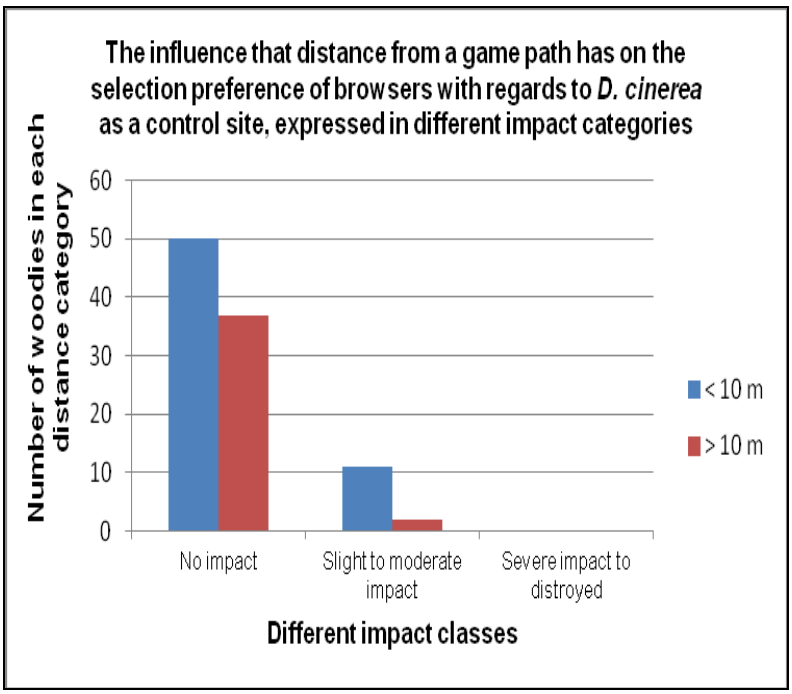

Figure 8: Distance from a game path and the selection preference of browsers for *D. cinerea* not treated with molasses on MGR, North West Province, South Africa

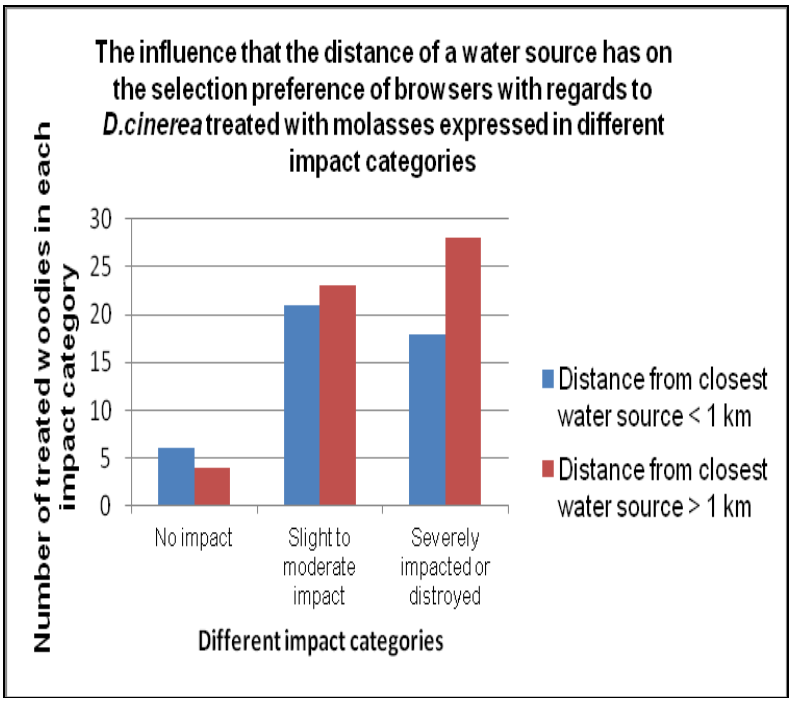

Figure 9: Distance from a water source and the selection preference of browsers for treated *D. cinerea* individuals on MGR, North West Province, South Africa

The red sandy soils and black clay soils on which the treated and control individuals occurred were also compared to determine if browsers preferred selecting *D. cinerea* individuals associated with a

Journal of Animal &Plant Sciences, 2016. Vol.28, Issue 3: 4456-4456
Publication date 1/05/2016, **http://www.m.elewa.org/JAPS***; ISSN 2071-7024*

particular "soil colour", assuming that different soil textures could influence the palatability of the plants. A total of 76 sites occurred on red sandy soils. Impact on the treated individuals located on the red sandy soils can be summarized as follows: 8 (11%) showed no impact, 29 (38%) showed slight to moderate impact and 39 (51%) showed severe impact or were destroyed. The black clay soils contained 24 treated sites of which 2 (8%) had no impact, 15 (63%) had slight to moderate impact and 7 (29%) had severe impact or was completely destroyed (Figure 11). Of the 76 untreated individuals occurring on red sandy soils, 66 (87%) had no impact and 10 (13%) had slight to moderate impact. No browse impact was recorded in the severely impacted to destroyed category. A total of 24 control sites were located on black clay soils, of which 21 (88%) showed no impact and 3 (12%) showed slight to moderate impact, with no impact recorded in the severely impacted on to destroyed category (Figure 12). Figures 11 and 12 clearly indicate that, irrespective of soil texture, browsers do select treated individuals rather than the untreated control plants. The larger portion (76%) of all sample sites occurred on red sandy soils. This largely explains the difference between the red sandy and black clay soils, as illustrated in Figures 11 & 12.

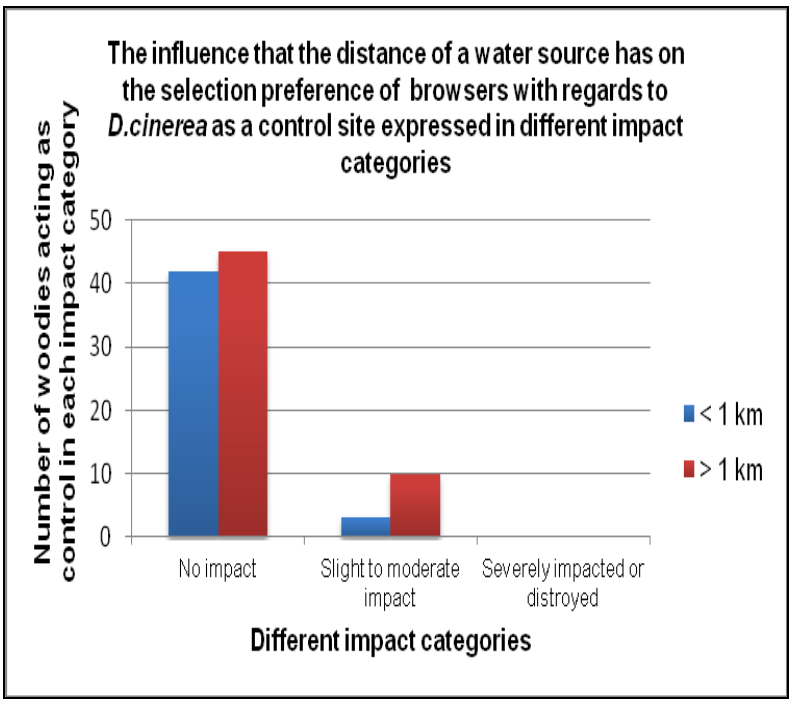

Figure 10: Distance from a water source and the selection preference of browsers for untreated *D. cinerea* individuals on MGR, North West Province, South Africa

Journal of Animal &Plant Sciences, 2016. Vol.28, Issue 3: 4456-4456
Publication date 1/05/2016, **http://www.m.elewa.org/JAPS***; ISSN 2071-7024*

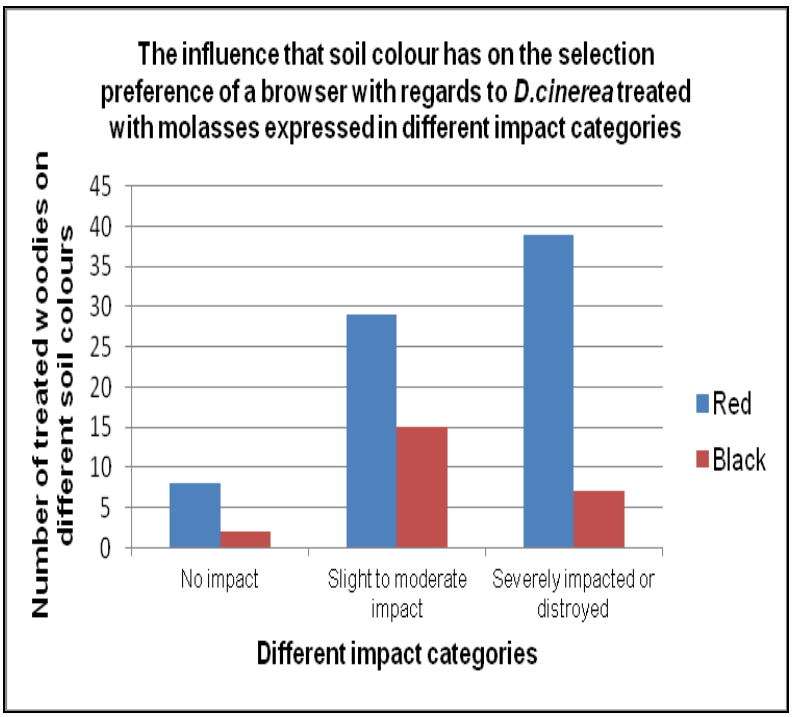

Figure 11: Influence of soil colour on the selection preference of browsers for *D. cinerea* treated with molasses on MGR, North West Province, South Africa

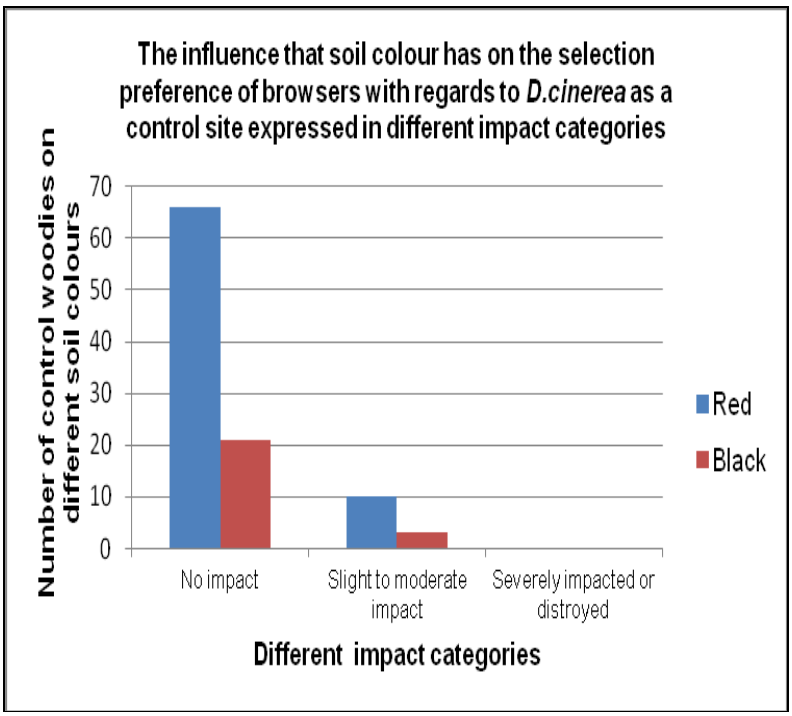

Figure 12: Influence of soil colour (red sandy soil and black clay soils) on the selection preference of browsers for *D. cinerea* not treated with molasses on MGR, North West Province, South Africa.

Journal of Animal &Plant Sciences, 2016. Vol.28, Issue 3: 4456-4456
Publication date 1/05/2016, **http://www.m.elewa.org/JAPS***; ISSN 2071-7024*

A further comparison was made between multi- and single stemmed *D. cinerea* individuals, although *D. cinerea* tends to be multi-stemmed rather than single stemmed plant. The 100 sample sites surveyed consisted of 19 single stemmed individuals with the remaining 81 individuals being multi-stemmed. The single stemmed individuals can be summarized as follows: 2 (11%) showed no impact, 7 (37%) showed slight to moderate impact and 10 (53%) showed severe impact or were destroyed. The 81 multi-stemmed individuals showed, 8 (9%) with no impact, 37 (46%) with slight to moderate impact and 36 (44%) with severe impact or were completely destroyed (Figure 13). The *D. cinerea* control plots had 19 single stemmed individuals, of which 16 (84%) were recorded with no impact, 3 (16%) recorded with slight to moderate impact and no recordings were made for the severely impacted or completely destroyed category. There were 81 control sites which were multi-stemmed *D. cinerea* individuals with 71 (88%) recorded with no impact, 10 (12%) recorded with slight to moderate impact and no individuals were recorded in the severely impacted on to completely destroyed category (Figure 14). Considering the difference in the number of multi-stemmed individuals in relation to single stemmed individuals, it is suggested that the woody individuals were not selected due to growth form but rather on treatment with molasses.

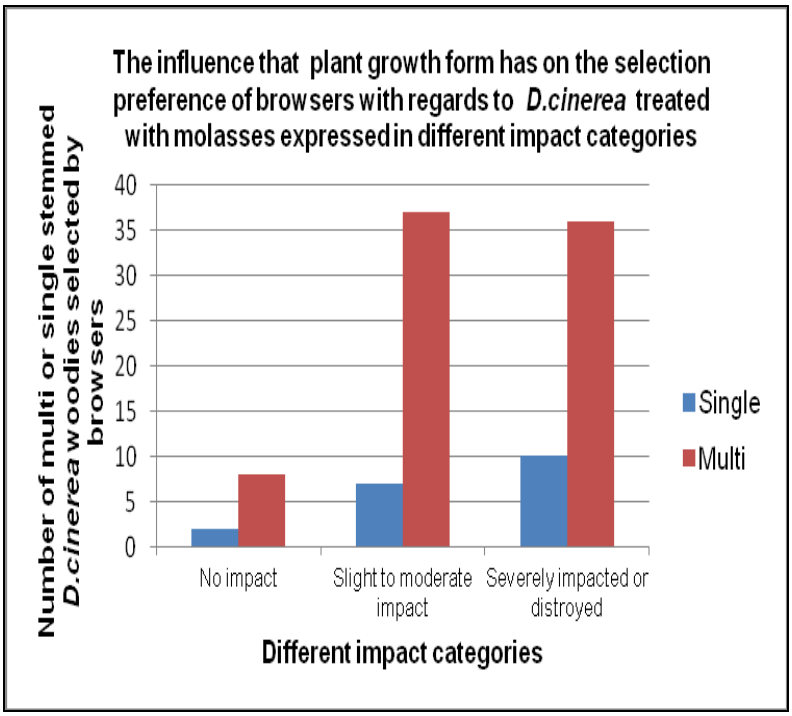

Figure 13: Influence of plant growth form on the selection preference of browsers for *D. cinerea* treated with molasses on MGR, North West Province, South Africa

Journal of Animal &Plant Sciences, 2016. Vol.28, Issue 3: 4456-4456
Publication date 1/05/2016, **http://www.m.elewa.org/JAPS***; ISSN 2071-7024*

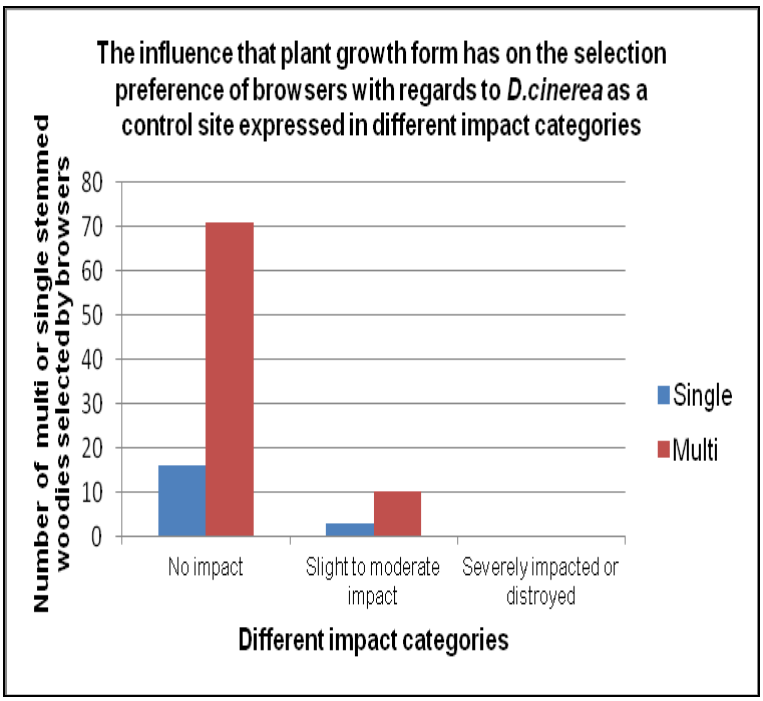

Figure 14: Influence of plant growth form on the selection preference of browsers for *D. cinerea* not treated with molasses on MGR, North West Province, South Africa

6 CONCLUSION

This pilot study confirmed, with statistical significance, that molasses as an energy supplement does indeed lure browsers, primarily elephants, to feed on the treated *D. cinerea* individuals, irrespective of clay content of the soils and distance from game paths or water sources. This approach might also be viable in areas without elephants if the *D. cinerea* stands are still in the initial stages of encroachment, represented by small dwarf shrubs, within the reach of other browsers. The approach could be tested on larger stands of *D. cinerea* and even include other encroacher species like *Senegalia* or *Vachellia*. The use of molasses to increase utilization by both grazers (Unal *et al.,* 2005) and browsers (this study) suggests the possible use of this approach to potentially control other unwanted herbaceous weeds. The growth forms associated with most weeds further suggests a wider spectrum of browsers utilizing these plants. The use of molasses to control other woody species and unwanted weeds however requires further research.

7 REFERENCES

Davies R: 1997. A Description and History of Madikwe Game Reserve, Rustenburg, Bop Print.

De D and Singh GP: 2003. Effect of cold process monensin enriched urea molasses mineral blocks on performance of crossbred calves fed, a wheat straw based diet. *Animal Feed Science and Technology.* 103: 51-61.

Donaldson CH: 1973. Some thoughts on the economics of bush eradication with special reference to the black thorn problem of the Molopo area. Unpublished report. Roodeplaat Research Station, Pretoria.

Everitt BS: 1998. Dictionary of Statistics, Cambridge University Press, Cambridge, Pg85.

Gammon DM: 1984. Effects of bush clearing, stocking rates and grazing systems on vegetation and cattle gains. Vleisraadfokus, May/June.3:9-18.

Heitschmidt RK, Schultz RD. and Scifres CJ: 1986. Herbaceous biomass dynamics and net primary production following chemical control of honey mesquite. *Journal of Range Management*. 39:67-71.

Jacoby PW, Meadors CH, Foster MA. and Hartmann FS: 1982. Honey mesquite control and forage response in Crane Country, Texas. *Journal of Range Management*. 35:424-426.

Moore A and Odendaal A: 1987. Die ekonomiese implikasies van bosverdigting en bosbeheer soos van toepassing op 'n speenkalfproduk siestelsel in die doringbosveld van die Molopo gebied. *Journal of the Grassland Society of Southern Africa*. 4:139-142.

Moore A, Van Niekerk JP, Knight IW. and Wessels H: 1985. The effect of Tebuthiuron on the vegetation of the thorn bushveld of the Northern-Cape: a preliminary report. *Journal of the Grassland Society of Southern Africa*. 2:7-10.

Scholes RJ: 1987. Response of three semi-arid savannas on contrasting soils to the removal of the woody component. Ph.D. thesis, University of the Witwatersrand, Johannesburg, South Africa.

Smit GN, Richter CGF. and Snyman HA: 2001. The influence of tree density on the grass layer of three semi-arid savannah types of Southern Africa. *African Journal of Range and Forage Science*. 18:103-109.

Smit GN: 2005. Tree thinning as an option to increase herbaceous yield of an encroached semi-arid savannah in South Africa. *BMI Ecology*. 2005 5:4

Srinivas B and Gupta BN: 1997. Rumen fermentation, bacterial and total volatile fatty acid (TVFA) production rates in cattle fed on urea molasses mineral blocks licks supplement. *Animal Feed Science and Technology*. 65: 275-286.

Toppo S, Verma AK, Dass RS. and Mehra UR: 1997. Nutrient utilization and rumen fermentation pattern in crossbred cattle fed different planes of nutrition supplemented with urea molasses mineral block. *Animal Feed Science and Technology*. 64: 101-112.

Unal Y, Kaya I. and Oncuer A: 2005. Use of urea molasses mineral blocks in lambs fed with straw. *Preventive Veterinary Medicine*. 156: 217–220.

Van Niekerk JP. and Kotze T: 1977. Chemical control of bush encroachment by means of aerial spraying. Proceedings of the Second National Weed Conference of Southern Africa, 165-184.

Verma AK, Mehra UR. and Dass RS: 1998. Nutrient Utilization by Murrah buffaloes (*Bubalus bubalis*) as influenced by varying levels of urea molasses mineral block on wheat straw bases diets. *Animal Feed Science and Technology*. 73: 339-346.

Vu DD, Cuong LX, Dung CA. and Hai PH: 1999. Use of urea molasses multi-nutrient block and urea treated rice straw for improving dairy cattle productivity in Vietnam. *Preventive Veterinary Medicine*. 38: 187-193.

Ward D: 2005. Do we understand the causes of bush encroachment in African savannas? *African Journal of Range and Forage Science*. 22:101–105.