Tropical Animal Health and Production, 35 (2003) 365–372

Dry Matter and Crude Protein Degradability of Four Parasitic Plants (Mistletoes) Associated with Browse Trees in Botswana

O.R. Madibela[1]*, S. Mabutho[2] and B. Sebolai[2]
[1]*Sebele Station, Department of Agricultural Research, Gaborone;* [2]*Department of Basic Sciences, Botswana College of Agriculture, Gaborone, Botswana*
**Correspondence: Department of Animal Science and Production, Botswana College of Agriculture, P/Bag 0027, Gaborone, Botswana*
E-mail: omadibel@temo.bca.bw

Madibela, O.R., Mabutho, S. and Sebolai, B., 2003. Dry matter and crude protein degradability of four parasitic plants (mistletoes) associated with browse trees in Botswana. *Tropical Animal Health and Production*, **35(4)**, 365–372

ABSTRACT

Four parasitic plants (*Tapinanthus lugardii*, *Erianthenum ngamicum*, *Viscum rotundifolium* and *Viscum verrucosum*) associated with browse trees in Botswana were evaluated for the degradability of their dry matter (DM) and crude protein (CP). All these plants have high levels of crude protein, ranging from 144.5 to 163.4 g/kg DM, with a significant ($p < 0.001$) difference in crude protein content between the plants. The rate of degradation of DM was highest for *V. rotundifolium* (0.197 h^{-1}) and lowest for *E. ngamicum* (0.031 h^{-1}). The two *Viscum* species had the highest effective DM degradability at an outflow rate of 0.05%. The rate of degradation of crude protein was highest for *V. rotundifolium* (0.144 h^{-1}) and lowest for *T. lugardii* (0.0346 h^{-1}). The effective degradability (ED) of crude protein was highest for *V. rotundifolium* at 0.03 and 0.05 h^{-1} outflow rates. *T. lugardii* and *E. ngamicum* had an apparently low effective degradability, but this may result from an association of their protein with tannins, which would be able to supply amino acids in the small intestine after dissociation due to the abomasal pH.

Keywords: browse, crude protein, degradability, dry matter, fistula, goat, mistletoe, parasitic plant, tannins

Abbreviations: ADF, acid detergent fibre; DM, dry matter; CP, crude protein; ED, effective degradability, LSD, least significant difference

INTRODUCTION

Green forage/fodder from grasslands is only available for a maximum of 5 months in a year in Botswana, so ruminant animals have to depend on poor-quality standing 'straw' and crop residues. However, the rangelands in Botswana contain many browse plants in the genera *Acacia*, *Boscia*, *Combretum* and *Grewia*. These are rich in proteins and minerals (Aganga *et al.*, 1999). During the extended dry seasons, conserved or purchased fodder and supplements are needed. High-quality feedstuffs that could be used for supplementation under these circumstances include cereal grains, fishmeal, oilseed cakes and animal by-products, but these are often not accessible to smallholder

farmers. With the recent outbreak of bovine spongiform encephalopathy in Europe, feeds derived from animal products are considered hazardous by both farmers and government. Therefore, there is a continuous need to search for and characterize feed resources that are disease risk-free, sustainable and acceptable to smallholder farmers.

For a long time, natural trees and shrubs have sustained both animal production and wildlife, but it is only recently that agricultural scientists have paid attention to them. According to Abdulrazak and colleagues (2000), the use of browse species as fodder for ruminants is becoming increasingly important in many parts of the tropics. These trees and shrubs have the potential to supply trace minerals, bypass protein and vitamins (Kibon and Ørskov, 1993).

Common parasitic plants found in the semi-arid conditions of Botswana are the mistletoes that attach themselves to branches of *Acacia* species, *Boscia albitrunca*, *Ziziphus mucronata* and other trees. In order to survive, these parasitic plants have become adapted to growing not in the soil like ordinary plants but within the living tissue of other plants, and procure at least some of their nutrients from living plants (Visser, 1981). Small farmers have reported harvesting these parasitic plants and feeding them to their ruminant animals. Madibela and colleagues (2000, 2002) studied the parasitic plants *Tapinanthus lugardii*, *Erianthenum ngamicum Viscum rotundifolium* and *Viscum verrucosum* and found that they had a high nutritive value. However, Elhassan and colleagues (2000) reported that, although chemical analysis is essential for understanding the nutritional potential of a new plant species, it is not a sufficient indicator of the processes that take place inside the rumen. Degradation studies are important because plants may have structural and toxic factors that limit fermentation by ruminal microbes. No study has been carried out to determine the degradabilities of parasitic plants. Therefore, the objective of this study was to determine the dry matter and protein degradability of parasitic plants (*T. lugardii*, *E. ngamicum*, *V. rotundifolium* and *V. verrucosum*) when incubated in the rumen of goats.

MATERIALS AND METHODS

Location of study

Samples of *T. lugardii*, *E. ngamicum*, *V. rotundifolium* and *V. verrucosum* (including 15–20 cm of shoots) were collected at Sebele Research Station in 1999. The station is situated at latitude 24°33′ S and longitude 25°57′ E, at an altitude of 994 m above sea level. The vegetation type is a mixture of *Acacia* savanna with broad-leaved middle layer trees like *Combretum apiculatum*, *Burkea africana* and others. The grass layer consists of species with intermediate forage value, such as *Eragrostis rigidior* and *E. lehmanmiana*. Species rated good in forage value include *Panicum maximum*, *Digitaria milanjiana*, *Urochloa mosambicensi* and *U. trichopus*. Grasses of poor nutritional value are *Aristida congesta* and *Melinis repens* (Madibela *et al.*, 2000).

Sampling and chemical analysis

Samples of each parasitic plant were harvested from 3 or 4 host trees available on the station and bulked together. Subsamples of 300 g of each plant were obtained from the bulked lot and dried in a forced air oven at 60°C for 48 h. Thereafter, the sample was ground to pass through a 2 mm screen and analysed for nitrogen by the Kjeldahl method (AOAC, 1996).

Dry matter and protein degradability

The nylon bag procedure was carried out in two fistulated goats (Ørskov *et al.*, 1980). Each plant was weighed out in duplicate and approximately 2.5 g samples were placed into weighed and numbered nylon bags. Incubation was divided into two periods and each of the goats received 12 bags from two different plants during each period. The bags were embedded in the rumen ingesta. The animals were cared for according to international guidelines for biomedical research involving animals (CIOMS, 1985). During the 14 days before the incubation commenced, the goats were fed an equal mixture of *Cenchrus ciliaris* (harvested at full maturity) and *Lablab purpureus* hay (machine-cut at the flowering stage, dried for 3 weeks and thereafter baled) at a rate of 700 g per animal per day. This mixture contained (g/kg DM) 76.8 crude protein, 7.8 calcium, 1.2 phosphorus, 733.1 neutral detergent fibre, 516.4 acid detergent fibre and 853.4 organic matter. Clean water was available to the goats all the time.

For ease of withdrawal, the nylon bags were fastened and secured to the fistula with a length of nylon string. At 0, 6, 12, 24, 48, 72 and 96 h after insertion, one bag for each plant was removed and rinsed with tap water. The bags were accumulated in a deep freezer (–20°C) until the incubation period was completed. The 0 h sample was not incubated but was washed with the rest during the washing stage. After all the bags had been withdrawn, they were washed under tap water until the water ran clear. The bags were then dried at 60°C for 48 h and weighed to determine the quantity of DM remaining as undigested material. DM degradability was expressed as the amount of DM that had disappeared after weighing the residue. Crude protein degradability was estimated as the difference between the concentration of protein in the initial sample and that in each residue.

Statistical analysis

The crude protein (CP) data and degradation constants (a, b, c, ED) were analysed using one-way analysis of variance and general non-linear models (NLIN) procedures (SAS, 1990), respectively. The means were separated using the least significant difference (LSD). Disappearance data for both DM and CP at the various stages of incubation were expressed as the percentages of the original amounts incubated and the results were fitted to the Ørskov and McDonald (1979) exponential model: $P = a + b(1 - e^{-ct})$, where P is the dry matter or protein that has disappeared at time t, a is

the zero-time intercept, b is the slowly degradable fraction and c is the rate of degradation. The degradability data were analysed to estimate the degradation constants using the SAS (Rowett Research Institute, Aberdeen, Scotland) computer program modified for the current data set. The effective degradability (ED) of DM or CP was calculated using the equation ED = $a + (bc/(c + k))$ (Ørskov, 1982), where k is the fractional outflow rate from the rumen, which was assumed to be 0.03 h^{-1} or 0.05 h^{-1}.

RESULTS

Crude protein content

Table I presents the crude protein content before incubation in the rumen of the goats. *Viscum* species had the highest concentrations of CP followed by *E. ngamicum*, and *T. lurgardii* had the lowest. *V. rotundifolium* and *V. verrucosum* had similar (p = 0.744) crude protein contents.

TABLE I
Mean crude protein concentration and its standard error for undigested parasitic plants

Plant	Number of samples	Crude protein (g/kg DM)
V. verrucosum	3	162.0 ± 1.2^{a}
V. rotundifolium	4	162.5 ± 1.1^{a}
T. lugardii	4	145.7 ± 1.1^{c}
E. ngamicum	4	157.2 ± 1.1^{b}

[abc]Values with same superscript within a column are not significantly different; $p < 0.05$

Degradability of dry matter and crude protein

Tables II and III show the degradability constants a, b and c and effective degradability (ED) estimates for DM and CP at fractional outflow rates from the rumen of 0.3 h^{-1} and 0.05 h^{-1}. The soluble fraction (a) in the DM ranged from 36.0 to 43.3 and there was no significant difference ($p > 0.05$) between the plants. No significant ($p > 0.05$) difference was observed between the plants for the insoluble but potentially degradable fraction (b) in DM. The rate of degradation (c) for DM was affected ($p < 0.05$) by plant species, being higher for *V. rotundifolium*. The ED for DM at a passage rate of 0.03 h^{-1} did not differ significantly ($p > 0.05$) between the plants but it did differ ($p < 0.05$) at a passage rate of 0.05 h^{-1}. However, *V. rotundifolium* had the highest ED values at both passage rates.

TABLE II
In situ dry matter (% DM) degradability constants and calculated effective degradability (ED) at two passage rates for the parasitic plants *V. verrucosum*, *V. rotundifolium*, *T. lugardii*, *E. ngamicum*

	Degradability constants			ED at different passage rates	
Plant	*a*	*b*	*c*	$k = 0.03$	$k = 0.05$
V. verrucosum	41.0	44.2	0.083^{b}	66.3	62.3^{ab}
V. rotundifolium	36.0	44.0	0.197^{a}	74.2	71.1^{a}
T. lugardii	39.7	44.1	0.039^{b}	64.6	59.0^{b}
E. ngamicum	43.3	46.2	0.031^{b}	64.7	59.5^{b}
Standard deviation	8.01	1.47	0.052	3.63	3.91

Constants *a*, *b* and *c* are described by the equation $P = a + b(1 - e^{-ct})$, where *P* is the dry matter disappearance at time *t*; *a* is the zero-time intercept; $a + b$ = the total degradability; *c* is the rate of degradation (h^{-1}). ED is the effective degradability calculated using the equation $ED = a + (bc/(c + k))$, where *k* is the outflow rate from the rumen assumed to be either 0.03 or 0.05 h^{-1}

[ab]Values with the same superscript within a column are not significantly different; $p < 0.05$

TABLE III
In situ crude protein (% DM) degradability constants and calculated effective degradability (ED) at two passage rates for the parasitic plants *V. verrucosum*, *V. rotundifolium*, *T. lugardii*, *E. ngamicum*

	Degradability constants			ED at different passage rates	
Plant	*a*	*b*	*c*	$k = 0.03$	$k = 0.05$
V. verrucosum	33.3	44.4	0.050^{b}	57.1^{ab}	52.4^{ab}
V. rotundifolium	28.3	43.9	0.144^{a}	64.6^{a}	60.8^{a}
T. lugardii	14.9	42.5	0.035^{b}	37.6^{b}	32.3^{b}
E. ngamicum	14.7	43.9	0.066^{ab}	43.3^{ab}	38.3^{ab}
Standard deviation	7.02	1.29	0.033	8.69	8.68

Constants *a*, *b* and *c* are described by the equation $P = a + b(1 - e^{-ct})$, where *P* is the dry matter disappearance at time *t*; *a* is the zero-time intercept; $a + b$ = the total degradability; *c* is the rate of degradation (h^{-1}). ED is the effective degradability calculated using the equation $ED = a + (bc/(c + k))$, where *k* is the outflow rate from the rumen assumed to be either 0.03 or 0.05 h^{-1}

[ab]Values with the same superscript within a column are not significantly different; $p < 0.05$

The degradability constants *a* and *b* for crude protein did not differ significantly ($p > 0.05$) between the plants. The rate of degradation, *c*, differed significantly ($p < 0.05$) between plants, *V. rotundifolium* having the highest value.

DISCUSSION

The mean CP for all the plants of 156.5 g/kg was higher than the values reported by Madibela and colleagues (2000, 2002). The CP content of the four parasitic plants in this study was similar to that of *Lablab purpureus* (158.0 g/kg), as reported by Pelaelo (1994). This result is encouraging, since *L. purpureus* is a leguminous fodder used in Botswana for supplementing ruminants.

The DM and CP values were higher than those found by Baloyi and colleagues (1997) for an indigenous browse tree, *Brachystegia spiciformis*, in Zimbabwe and by Aldulrazak and colleagues (2000) for some *Acacia* tree leaves from Kenya. The value for the insoluble but potentially degradable fraction (*b*) in the DM in the present study was similar to the values reported by Baloyi and colleagues (1997), Abdulrazak and colleagues (2000) and El hassan and colleagues (2000) for leguminous fodder trees. The high ED for *V. rotundifolium* may be due to the high rate of passage (Abdulrazak *et al.*, 2000) and low ADF content (Madibela *et al.*, 2000). However, for all the plants there was a general trend to a reduction in degradability when the outflow rate was increased from 0.03 h^{-1} to 0.05 h^{-1}, a phenomenon also observed by Baloyi and colleagues (1997).

The tendency for *V. verrucosum* and *V. rotundifolium* to have higher values for *a* and *b* (Table III) may be consistent with their high CP content (Table I). El hassan *et al.* (2000) reported that the rate of degradation of *Medicago sativa* was higher than those for *Acacia angustissima* or *Leucaena leucocephala* (0.020 h^{-1} and 0.026 h^{-1}, respectively), which were lower than those of any plant in the present study. The decrease in the ED of DM and CP had the effect of changing the ranking order of feeds, so assessing the degradability at one particular outflow rate can be misleading (Ørskov, 1982). This implies that different feeding conditions that result in different outflow rates would give different performances from different protein supplements. *V. rotundifolium* had the highest ED, which was similar to that of *V. verrucosum* and *E. ngamicum*. A possible explanation of the high ED of *V. rotundifolium* could be its low level of ADF. Other factors, such as tannins, seasonal variability and the agronomic characteristics of the host plant, may contribute to the differences in degradation of these plants. Madibela and colleagues (2002) recently found that *V. rotundifolium* contains relatively little (31 g/kg) condensed tannins compared to 56, 65 and 75 g/kg DM for *T. lurgardii*, *E. ngamicum* and *V. verrucosum*, respectively. Jones and colleagues (2001) reported that condensed tannins bind to dietary protein and so reduce the digestibility of the protein. It is possible the high ED of *V. rotundifolium* was because it had less tannin binding to its protein. Although some condensed tannins may protect plant protein from digestion in the rumen, subsequent dissociation of the complex at abomasal pH will provide amino acids for absorption in the small intestine (Waghorn *et al.*, 1987, as cited by McSweeney *et al.*, 1999); the extent of this dissociation and its benefits to the

animal are not certain. This is because the plant tannins contained in specific forage and browse plants can have positive or negative effects on nitrogen use and overall livestock performance, depending on the types and concentration of tannins that are present (Turner, 2001).

Thus, all the parasitic plants investigated have high levels of crude protein. The effective degradability for crude protein was less than 50% for *T. lurgardii* and *E. ngamicum*, which means that a large proportion of the protein will leave the rumen without being degraded, probably because of binding with antinutritional factors. However, the extent of protein digestion in the small intestine is unknown for these plants and needs to be investigated, since hydrolysis with tannins may be reversible in acidic conditions in the abomasum, while a condensation reaction is irreversible (Ørskov, 1982).

ACKNOWLEDGEMENTS

The authors thank the staff of the Plant and Feed Analytical Laboratory (DAR) for their help with the analytical work. J. Makore is acknowledged for his statistical input. This work was submitted as part of the requirement for a Diploma in Agriculture (Botswana College of Agriculture/University of Botswana) by the second author. This study was funded by the Ministry of Agriculture of Botswana.

REFERENCES

Abdulrazak, S.A., Fujihara, T., Ondiek, J.K. and Ørskov, E.R., 2000. Nutritive evaluation of some *Acacia* tree leaves from Kenya. *Animal Feed Science and Technology*, **85**, 89–98

Aganga, A.A. and Monyatsiwa, C.B., 1999. Use of browse (*Terminalia serecia*, *Combretum apiculatum* or *Euclea schimperi*) as supplement for growing Tswana goats. *Tropical Animal Health and Production*, **31**, 295–305

AOAC, 1996. *Official Methods of Analysis*, (Association of Official Analytical Chemists, Washington DC)

Baloyi, J.J., Ngongoni, N.T., Topps, J.H. and Ndlovu, P., 1997. Chemical composition and degradability of *Brachystegia speciformis* (musasa) leaves and stems harvested over 4 months from tree sites in Zimbabwe. *Animal Feed Science and Technology*, **69**, 179–186

CIOMS, 1985. *International Guiding Principles for Biomedical Research Involving Animals*, (Council for International Organization of Medical Sciences, Geneva)

El-hassan, S.M., Lahlou, A., Kassi, A., Newbold, C.J. and Wallace, R.J., 2000. Chemical composition and degradation characteristics of foliage of some African multipurpose trees. *Animal Feed Science and Technology*, **86**, 27–37

Jones, R.J., Meyer, J.H.F., Bechaz, F.M., Stoltz, M.A., Palmer, B. and van de Merwe, G., 2001. Comparison of rumen fluid from South African game species and from sheep to digest tanniniferous browse. *Australian Journal of Agricultural Research*, **52**, 453–460

Kibon, A. and Ørskov, E.R., 1993. The use of degradation characteristics of browse plants to predict intake and digestibility by goats. *Animal Production*, **57**, 247–251

Madibela, O.R., Boitumelo, W.S. and Letso, M., 2000. Chemical composition and *in vitro* dry matter digestibility of four parasitic plants (*Tapinanthus lurgardii*, *Eriathenum ngamicum*, *Viscum rotundifolium* and *Viscum verrucosum*) in Botswana. *Animal Feed Science and Technology*, **84**, 97–106

Madibela, O.R., Letso, M., Boitumelo, W.S., Masedi, M. and Alton, K., 2002. Chemical composition of four parasitic plants harvested over a period of six months from two sites in Botswana. *Animal Feed Science and Technology*, **95**, 159–167

McSweeney, C.S., Dalrymple, B.P., Gobius, K.S., Kennedy, P.M., Krause, D.O., Mackie, R.I. and Xue, G.P., 1999. The application of rumen biotechnology to improve the nutritive value of fibrous feedstuffs; pre- and post ingestion. *Livestock Production Science*, **59**, 265–283

Ørskov, E.R., 1982. *Protein Nutrition in the Ruminant*, (Academic Press, London)

Ørskov, E.R. and McDonald, I., 1979. The estimation of protein degradability in the rumen from incubation measurements weighted according to rate of passage. *Journal of Agricultural Science (Cambridge)*, **92**, 499–503

Ørskov, E.R., DeB Hovell, F.D. and Mould, F., 1980. The use of nylon bag technique for the evaluation of feedstuffs. *Tropical Animal Production*, **5**, 195–213

Pelaelo, D.T., 1994. *Potential rumen bypass protein of common legume feeds for livestock in Botswana*, (BSc dissertation, Botswana College Agriculture/University of Botswana)

SAS, 1990. *SAS User's Guide. Statistics*, version 6, (SAS Institute, Inc., Cary, NC)

Turner, K.E., 2001. Tannins and protein utilization relationships in small ruminant grazing and browsing systems. *Journal of Animal Science*, **79** (Supplement 2), 27 (abstract)

Visser, J., 1981. *South African Parasitic Flowering Plants*, (Juta, Cape Town)

Waghorn, G.C., Ulyatt, M.J., John, A. and Fisher, M.T., 1987. The effect of condensed tannins on site of digestion of amino acids and other nutrients in sheep fed on *Lotus corniculatus* L. *British Journal of Nutrition*, **57**, 115–126

(Accepted: 16 March 2002)

Dégradation des matières sèches et des protéines brutes de quatre plantes parasitiques (gui) associées à des arbres broutés au Botswana

Résumé – Quatre plantes parasitiques (*Tapinanthus lugardii, Erianthenum ngamicum, Viscum rotundifolium* et *Viscum verrucosum*) associées à des arbres broutés au Botswana ont été évaluées afin de déterminer la dégradation de leur matière sèche (DM) et des protéines brutes (CP). Toutes ces plantes avaient des taux élevés de protéine allant de 144,5 à 163,4 g/kg de DM, avec une différence significative ($p < 0{,}01$) dans la teneur en protéines brutes entre les plantes. La vitesse de dégradation de la DM a été la plus élevée pour *V. rotundifolium* (0,197 h^{-1}) et la plus basse pour *Ngamicum* (0,031 h^{-1}). Les deux espèces de *Viscose* avaient la dégradation effective de DM la plus élevée à une vitesse de dégradation de 0,05%. La vitesse de dégradation de la protéine brute a été la plus élevée pour *V. rotundifolium* (0,144 h^{-1}) et la plus basse pour *T. lugardii* (0,0346 h^{-1}). La dégradation effective (ED) de la protéine brute a été la plus élevée pour *V. rotundifolium* à des vitesses de dégradation de 0,03 et 0,05 h^{-1}. *T. lugardii* et *E. ngamicum* ont présenté une dégradation effective basse en apparence, mais ceci a probablement été dû à l'association de leur protéine à des tannins susceptibles de produire des acides aminés dans l'intestin grêle après une dissociation imputable au pH abomasal.

Degradabilidad de la materia seca y de la proteína bruta de cuatro plantas parásitas (muérdago) de los árboles forrajeros en Botswana

Resumen – Se analizó la degradabilidad de la materia seca (DM) y de la proteína bruta (CP) de cuatro plantas parásitas (*Tapinanthus lugardii*, *Erianthenum ngamicum*, *Viscum rotundifolium* y *Viscum verrucosum*) de los árboles forrajeros en Botswana. Todas estas plantas presentaron un nivel elevado de proteína bruta, entre 144,5 y 163,4 g/kg de DM, pero con diferencias significativas ($p < 0{,}001$) entre ellas. La mayor tasa de degradación (c) de la materia seca correspondió a *V. rotundifolium* (0,197 h^{-1}), mientras que la más baja fue para *E. ngamicum* (0,031 h^{-1}). Las dos especies de *Viscum* presentaron la mayor degradabilidad efectiva de la DM con un tránsito de 0,05. La mayor tasa de degradación de la proteína bruta correspondió a *V. rotudifolium* con un tránsito de 0,03 y 0,05 h^{-1}. *T. lugardii* y *E. ngamicum* presentaron una degradabilidad efectiva aparentemente baja, pero esto puede deberse a la asociación de sus proteínas a los taninos, las cuales igualmente podrían aportar aminoácidos en el intestino delgado debido a la disociación provocada por el pH del abomaso.