Indian Journal of Animal Sciences **83** (4): 407–410, April 2013/Article

Eating pattern, nutrient utilization and rumen metabolites in goats fed *Dichanthium annulatum*-browse leaves diets

SULTAN SINGH[1] and S S KUNDU[2]

Indian Grassland and Fodder Research Institute, Jhansi, Uttar Pradesh 284001 India

Received: 12 December 2010; Accepted: 18 October 2012

ABSTRACT

The present study was conducted to assess the supplementary effect of tropical browse species leaves on feed intake, nutrients utilization, rumen metabolites and water kinetics of goats fed *Dichanthium annulatum* grass based diets. In an experiment 4 adult male local goats, weighing 30.0±2.1 kg, were fed *Dichanthium annulatum-Hardwickia binata* (DA-HB), *Dichanthium annulatum-Securegeia virosa* (DA-SV), *Dichanthium annulatum-Leucaena leucocephala* (DA-LL) and *Dichanthium annulatum-Helectris isora* (DA-HI) grass: tree leaves diets in 50: 50 ratios in 4 separate feeding trials. A digestion-cum-metabolism trial was conducted to determine intake, nutrients utilization and nitrogen (N) balance. Rumen liquor was collected at 0 and 4 h feeding after 60 and 90 days of feeding to estimate rumen metabolites, while for water kinetics rumen liquor was drawn once at 90 days of feeding from an individual goat in each trial. DMI of goats was highest on DA-HI and lowest on DA-HB diet. Goats exhibited higher digestibility of CP, NDF, ADF and cellulose on DA-HI than other diets. Faecal N loss was higher from DA-LL, while urinary N loss was more from DA-HI and DA-LL. N balance (g/d) was highest in DA-LL and lowest in DA-HB. Goats had higher eating rate at first and fourth hour of feeding on tested diets, while meal consumption was highest on DA-LL and lowest on DA-HB diet. Goat rumen liquor had higher TVFA and N metabolites on DA-LL. Goats exhibited higher dilution rate and out flow rate on DA-HI and DA-LL diets than DA-SV and DA-HB diets. Results revealed that goats had higher DMI and nutrients digestibility on DA-HI and DA-SV diets, while N balance and rumen metabolites production was more on DA-LL diets.

Key words: *Dichanthium annulatum*, Goats, Nitrogen balance, Rumen metabolites, Water kinetics

Goats are primarily reared under grazing and semi intensive system where grass and leaves of shrubs/trees are the major dietary source (Topps 1992, Mekoyo 2008). Leaves form browse plants rich in protein, vitamins and minerals (Aganga and Mesho 2008, Khan *et al.* 2009) are used to supplement grass and other low grade roughages to increase their feeding value for improved animal productivity (Mekoyo 2008). To narrow regional feed imbalances evaluation of area specific feed resources including leaves from browse plants is imperative as they make up a substantial part of livestock feeding, particularly for goats. *Helictris isora, Securenegia virosa, Leucaena leucocephala* and *Hardwickia binata* tree species available in Bundelkhand region were evaluated for their nutritive value (Chaurasia *et al*. 2006, Singh and Kundu 2010a) but information on influence of *Helictris isora, Securenegia virosa* and *Hardwickia binata* leaves on rumen function is lacking. The present study assess the supplementary effect of these tropical browse species leaves on feed intake, nutrients utilization, rumen metabolites and water kinetics of goats fed *Dichanthium annulatum* grass based diets.

Present address: [1]Principal Scientist (singh.sultan @rediffmail.com).[2]Principal Scientist and Head, Dairy Cattle Nutrition Division, NDRI, Karnal Haryana (sskundu.kln @gmail.com).

MATREIALS AND METHODS

Grass and tree leaves: Dichanthium annulatum (DA) grass was harvested at full bloom to mature stage from pure fields and conserved as hay. Browse leaves (*Hardwickia binata*-HB, *Leucaena leucocephala*-LL, *Securengia virosa*-SV and *Helictris isora*-HI) were collected from the trees of grazing fields and Institute nursery, dried under shade on polythene sheets and stored in gunny bags for animal feeding.

Animals, feeding and eating pattern: Four adult male goats of local breed were fed DA-SV, DA-HI, DA-LL and DA-HB diets in 4 separate feeding trials. Mean weight of goats was 30.2±2.6, 31.9±2.5, and 27.9±2.6 and 30.1±2.6 kg on DA-HI, DA-SV, and DA-LL and DA-HB diets, respectively. DA grass and tree leaves in 50: 50 ratios were offered to goats in each feeding trial for more than 90 days. Animals individually were offered half of the grass and tree leaves between 9: 00 and 9: 30 AM and remaining half in the evening between 3: 00 and 3: 30 PM. The animals were watered twice at 11: 00 AM and 3: 00 PM and were maintained under hygienic conditions.

Eating pattern of goats (50–55 days post feeding) on each tested diet was recorded for 3 consecutive days by offering half quantity each of grass and tree leaves at 9.00 AM and again at 1.00 PM. The feed intake of individual animal on each diet was recorded at 1 h, 2 h, 3 h, 4 h, 5 h, 7 h and 17 h post feeding.

Digestion-cum-metabolism trial: At about 60 days post feeding a digestibility-cum-metabolism trial of 7 days was conducted on each diet using metabolism cages. Faeces and urine samples of individual animal were collected for 24 h and pooled in polythene bags and cans, respectively. Representative samples of faeces were drawn for DM (1/50 aliquot) and N (1/100 aliquot preserved in 20% H_2SO_4) estimation during metabolism trial. For urinary N estimation a fixed volume (5 ml) of urine was pooled in digestion flasks (containing concentrated sulphuric acid) for individual animals during the collection period. Offered grass, tree leaves and orts samples were collected daily and representative samples were kept for DM estimation. Dried faeces, feeds offered and orts samples were ground using 1-mm sieve.

Rumen liquor collection: Rumen liquor from goats was drawn twice on each diet once at 60 and 90 days. Rumen liquor between 50–60 ml was collected into a 0.5 litre pre-warmed thermos with perforated plastic stomach tube using light suction at 0 and 4 h post feeding. The pH of rumen liquor was recorded immediately with digital pH meter and then strained through double layer of muslin cloth and stored in 50 ml plastic bottles after adding a few drops of saturated mercuric chloride.

Analytical techniques: Grass (DA), tree leaves (LL, HI, SV and HB), orts and faeces samples were subjected to estimation of DM, CP, ash (AOAC 1990) and NDF-without amylase, ADF, cellulose and lignin (Van Soest *et al.* 1991). Rumen liquor was analyzed for total nitrogen and protein nitrogen (McKenzie and Wallace 1954), ammonia-nitrogen (Conway 1962) and TVFA (Briggs *et al.* 1957) was used. Rumen water kinetics parameters viz. rumen volume, outflow rate and dilution rate were determined following methods of Smith (1959) and Hyden (1961) by infusing PEG-6000 dissolved in lukewarm water into the rumen with a stomach tube.

Statistical analysis: Data on intake, nutrient digestibility, N balance, eating pattern and rumen metabolites was analyzed with General Linear Model (GLM) of SPSS version 12.0 using multivariate analysis. The difference in means was tested using Duncan's Multiple Range Test as per Snedecor and Cochran (1968).

RESULTS AND DISCUSSION

Chemical composition: CP contents of all the 4 diets, viz. DA-LL, DA-SV, SA-HI and DA-HB were adequate to meet the maintenance requirement (NRC 2001) of goats; however the CP contents were highest in DA-LL and lowest in DA-HB diet. NDF and ADF contents were lower in DA-LL and SA-SV than other diets. The variability in grass-tree leaves diets may be due to the differences in CP and cell wall contents of DA grass and tree leaves (LL, SV, HI and HB).

Table 1. Chemical composition of grass-browse diets (% DM basis)

Attributes	DA-HI	DA-SV	DA-LL	DA-HB
OM	89.70	89.98	90.31	91.02
CP	8.56	8.40	12.10	7.62
NDF	54.94	50.05	49.85	54.81
ADF	31.31	27.93	28.51	35.31
Cellulose	24.06	23.23	20.82	24.48
HCL	23.63	22.12	21.34	19.50
Lignin	6.61	3.80	6.52	9.82

Intake and nutrients digestibility

Goats had higher ($P<0.05$) DMI on DA-HI diet than other 3 groups (Table 2). Nutritional composition of DA grass and browse leaves (HI, SV, LL and HB) reported earlier (Singh and Kundu 2010a) indicated that NDF content (% DM) was more in HB than HI, LL and SV leaves. Higher NDF contents of HB might be partly responsible for lower feed intake of goats on DA-HB diet. Woodward and Reed (1997) established an inverse relationship among palatability, intake and NDF contents of leguminous fodder trees.Goats DM intake in the range of 2.3–3.2% across evaluated DA grass-browse leaves diets is consistent with the reported values for tropical goats (Devendra and Burns 1983).

Goats exhibited comparatively higher ($P<0.05$) digestibility of DM, OM, NDF, ADF and cellulose on DA-HI and DA-SV diets (Table 2). Lower nutrients digestibility in goats on DA-HB diet may be attributed to higher fiber and lignin contents of HB (Singh and Kundu 2010a), while for DA-LL diet more phenolics and condensed tannin in LL than HI and SV (Negi *et al.* 2003) might have reduced the digestibility by binding with protein and carbohydrates (Hove *et al.* 2001).

Nitrogen balance: Nitrogen intake was higher ($P<0.05$) in goats on DA-LL and DA-HI than other 2 diets (Table 2). Goats highest ($P<0.05$) faecal N loss was on DA-LL and more urinary N loss on DA-HI diet. Goats were in positive N balance and N retention varied from 0.3 in DA-HB and 5.1 g/d on DA-LL diet. Higher faecal N loss in goats on DA-LL diet may be due to higher amount of N bound to cell wall as NDIN (Chaurasia *et al.* 2006) which lowered N degradability. Variability in N excretion in faeces and urine of goats fed DA grass-tree leaves based diets may be associated with the level of tannins in tree leaves (Negi *et al.* 2003).

Eating pattern: Goats exhibited higher eating rate on the

Table 2. Dry matter intake (DMI), nutrients digestibility and nitrogen balance of goats fed DA grass-tree leaves diets

Parameters	DA+HI	DA+SV	DA+LL	DA+HB	SEM
Intake					
g/d	986.6^{b}	808.1^{a}	787.6^{a}	716.2^{a}	42.5
% BW	3.2^{b}	2.40^{a}	2.8^{ab}	2.3^{a}	0.09
g/kg $w^{0.75}$	76.2^{b}	57.7^{a}	64.9^{ab}	53.9^{a}	1.69
Nutrients digestibility (%)					
DM	57.9^{b}	58.9^{b}	52.1^{a}	46.2^{a}	1.06
OM	60.6^{b}	62.3^{b}	55.9^{a}	48.8^{a}	1.19
CP	61.7^{c}	52.9^{b}	54.9^{b}	33.4^{a}	1.70
NDF	56.0^{b}	51.8^{b}	41.1^{a}	34.4^{a}	1.20
ADF	53.2^{c}	48.9^{c}	37.1^{b}	26.1^{a}	1.39
Cellulose	63.4^{b}	60.0^{b}	49.9^{a}	53.2^{a}	1.27
Hemicellulose	57.9^{a}	56.3^{a}	62.9^{a}	57.3^{a}	1.20
Nitrogen balance (g/d)					
Intake	16.5^{b}	12.1^{a}	19.9^{b}	11.0^{a}	0.7
Faecal-N	6.4^{a}	5.7^{a}	9.1^{b}	7.2^{b}	0.5
Digestible-N	10.1^{c}	6.4^{b}	10.9^{c}	3.8^{a}	0.3
Urinary-N	6.9^{b}	4.1^{a}	5.8^{b}	3.5^{a}	0.3
Retained-N	3.3^{b}	2.3^{b}	5.1^{c}	0.3^{a}	0.3

Means with letters a, b and c in columns within the same row differ significantly at P<0.05.

DA grass-tree leaves evaluated diets during first and fourth hour of feeding (Fig. 1). Within the diets goats eating rate was lowest on DA-HB at all the feeding hours except during second and fourth hour of feeding. Average feed DMI (g/h and g/kg $w^{0.75}$/h) in goats on DA-HB diet was significantly lower (P<0.05) than other 3 diets (Table 3). Lower dilution rate of DA-HB diet and higher fiber contents in HB leaves possibly resulted in rumen fill and more grinding and chewing time that collectively might have reduced intake in early hours of feeding.

Rumen metabolites and water kinetics: The rumen liquor pH varied from 6.6 to 7.5 on tested diets and was lower at 4 h post feeding than 0 h (before feeding). Mean pH of rumen liquor on DA-HI, DA-SV, DA-LL and DA-HB diets was 7.0, 7.4, 6.7 and 7.0, respectively (Table 4). Rumen liquor of goats

Table 3. Average meal size in goats fed DA grass-browse leaves diets

Meal size	DA+HI	DA+SV	DA+LL	DA+HB	SEM
Feed DMI g/h	38.1^{b}	38.8^{b}	42.8^{b}	25.1^{a}	1.1
DMI% body wt/h	129.9^{b}	125.2^{b}	154.7^{b}	80.3^{a}	4.3
Feed DMI g/kg $W^{0.75}$/h	3.0b^{c}	2.9^{b}	3.5^{c}	1.9^{a}	0.1
Feed intake g/h	58.5^{b}	64.5^{b}	46.8^{a}	45.5^{a}	1.4
Feed intake% body wt/h	194.2^{b}	211.1^{b}	169.8^{a}	145.4^{a}	6.1
Feed intake g/kg $W^{0.75}$/h	4.5^{b}	4.9^{b}	3.9^{a}	3.4^{a}	0.1

Means with letters a, b and c in columns within the same row differ significantly at P<0.05.

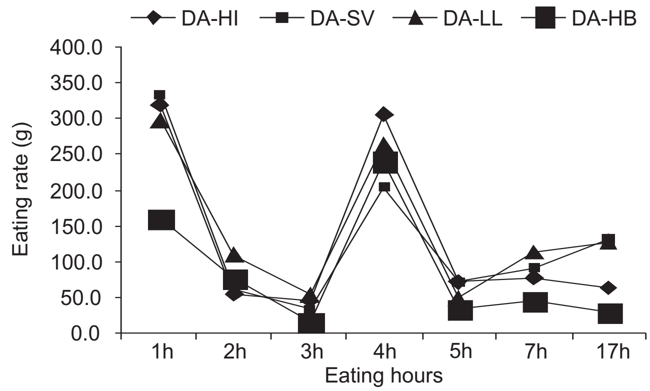

Fig. 1. Eating pattern of goats on *Dichantheum annulatum* grass-browse leaves based diets.

had higher (P<0.05) TVFA concentration on DA-LL (107.4) and lowest on DA-HB diet (57.5 meq/litre). Total N, NH_3-N and TCA soluble N in rumen liquor of goats was also (P<0.05) higher on DA-LL diet and lowest on DA-HB diet. The pH values (6.6 to 7.5) of goat's rumen liquor on DA grass tree leaves diets were within the range optimum for activity of cellulytic microbes (Erdmen 1988) and VFA absorption (Dijkstra *et al.* 1993). Higher protein content and moderate solubility of LL protein may be responsible for higher N

Table 4. Rumen metabolites concentration and water kinetics in goats on DA grass-browse leaves diets

Paramters	DA+HI	DA+SV	DA+LL	DA+HB	SEM
Rumen metabolites pH					
0h	7.1	7.5	6.8	7.1	
4h	6.9	7.4	6.6	6.9	
Mean	7.0a	7.4a	6.7a	7.0a	0.1
TVFA meq/l					
0h	74.9	70.7	100.1	54.5	
4h	88.6	104.3	114.6	60.4	
Mean	81.7^{a}	87.5^{ab}	107.4^{b}	57.5^{a}	3.5
Total-N mg/dl					
0h	83.5	99.4	114.45	66.27	
4h	98.3	105.3	139.8	70.9	
Mean	90.9^{b}	102.4^{b}	127.1^{bc}	68.6^{a}	3.1
NH_3-N mg/dl					
0h	16.8	15.4	26.9	14.0	
4h	19.1	22.6	37.4	16.8	
Mean	17.9^{a}	18.9^{a}	32.2^{b}	15.4^{a}	0.6
TCA sol N mg/dl					
0h	32.2	31.8	45.5	26.0	
4h	38.9	48.5	65.1	30.8	
Mean	35.6^{ab}	40.2^{b}	55.3^{c}	28.4^{a}	2.0
Water kinetics					
Rumen volume (litre)	7.6	6.9	6.5	6.8	0.1
Dilution rate (%)	9.9	6.2	9.1	5.4	0.1
Out flow rate l/d	10.5	7.3	9.3	6.7	0.1

Means with letters a, b and c in columns within the same row differ significantly at P<0.05.

metabolites concentration in rumen liquor of goats fed DA-LL diet. The NH_3-N concentration for all the diets was above the minimum concentration of 50 mg/l for microbial growth (Satter and Slyter 1974).

The rumen volume of goat varied from 6.5–7.6 litre on the evaluated DA grass-browse leaves diets (Table 4). Total out flow rate (l/d) and dilution rate (%) were highest on DA-HI diet (10.5 and 9.9) and lowest on DA-HB diet (6.7 and 5.4). The lower dilution rate on DA-HB diet should have increased the retention time of solids resulting in more DM degradation. But this did not happen in present study. Rumen volume, dilution rate and outflow rate in sheep on DA-tree leaves diets reported by Singh and Kundu (2010b) was lower than present study. This observation was supported by Domingue *et al.* (1991) who also observed rumen fluid volume in relation to live weight to be higher in goats than sheep.

Dry matter intake and nutrients digestibility in goats was higher on DA-HI and DA-SV diets. Rumen liquor of goats had higher TVFA and N metabolites concentration along with N retention on DA-LL diet. HB was not found to be a good supplement to DA grass, as on DA-HB diet intake, nutrients digestibility, N balance and rumen metabolites was lower than the other 3 diets.

REFERENCES

Aganga A A. and Mesho E O. 2008. Mineral contents of Browse plants in Kweneng district of Botswana. *Agricultural Journal* **3** (2): 93–98.

AOAC. 1990. *Official Methods of Analysis*. 13th edn. Association of Official Analytical Chemists, Washington D C.

Briggs P K, Hogen J P, Reid R I.1957. Effect of vol-atile fatty acids, lactic acid and ammonia on rumen pH in sheep. *Australian Journal of Agricultural Sciences* **8**: 674–90.

Chaurasia M, Kundu S S, Singh S, Mishra A K.2006 Cornell net carbohydrate and protein system for nutritional evaluation of tree leaves shrubs and grasses. *Indian Journal of Animal Sciences* **7**: 81–87.

Conway E J. 1962. *Micro Diffusion Analysis and Volumetric Error*. 5th edn. Van Nostrand, New York.

Devendra C and Burns C.1983. Trees and shrubs as sustainable feed resources. *Proceedings of II World Conference on Animal Production.* Edmonton, Alberta, Canada, 1 pp: 119–36.

Dijkstra J, Boer H, Van Bruchem J, Bruining M and Taminga S. 1993. Absorption of volatile acids from the rumen of lactating dairy cows as influenced by volatile acid concentration, pH and rumen liquid volume. *British Journal of Nutrition* **69**: 385–96.

Domingue B H F, Dellow D W and Barry T N. 1991. Voluntary intake and rumen digestibility of low quality roughages by goats and sheep. *Journal of Agricultural Science* (Cambridge) **117**: 111–20.

Erdman R A. 1988. Dietary buffering requirements of the lactating cows: a review. *Journal of Dairy Science* **71**: 3246–66.

Hove L, Topps J H, Sibanda S and Ndlovu L R. 2001 Nutritional intake and utilization by goats fed dried leaves of shrub legumes *Acacia angustissima, Calliandra calothyrus* and *Leucaena leucocephala* as supplement to pasture hay. *Animal Feed Science and Technology* **91**: 95–106.

Hyden S. 1961. The use of reference substances and measurement of out flow rate in alimentary tract. *Digestive Physiology and Nutrition of Ruminants*.pp: 37.Butterworth, London.

Khan N A, Habbib G and Ullah, G. 2009. Chemical composition, rumen degradability, protein utilization and lactation response to selected tree leaves as substitute of cotton seed cake in the diet of dairy goats. *Animal Feed Science and Technology* **154** (3–4): 160–68.

McKenzie H A and Wallace H S. 1954. The kjeldahl determination of nitrogen. *Australian Journal of Chemistry* **7**: 55–61.

Mekoyo A K. 2008. 'Multipurpose fodder trees in Ethiopia: farmer's perception, constraints to adoption and effect of long term supplementation on sheep performance.' Ph.D thesis, University of Wageningen.

Negi A S, Bhadoria B K, Nag S K and Kundu S S. 2003. Chemical composition of some brose species of Bundelkhand. *Animal Nutrition and Feed Technology* **3**: 53–59.

NRC. 2001. *Nutrients Requirements of Dairy Cattle*. National Academy Press, Washington, D C.

Satter L D and Slyter L L. 1974. Effect of ammonia concentration on rumen microbial protein production *in vitro. British Journal of Nutrition* **32**: 99–208.

Singh S and Kundu S S. 2010a. Effect of tropical browse leaves supplementation on rumen enzymes of sheep and goats fed *Dichanthim annulatum* grass- based diets. *Tropical Animal Health and Production* **42**: 1181–87.

Singh S and Kundu S S. 2010b. Intake, nutrient digestibility, rumen fermentation and water kinetics in sheep fed *Dichanthium annulatum* grass hay-tree leaves diets. *Livestock Research for Rural Development* **22** (8): http: //www.lrrd.org/lrrd22/8/ singh.htm.

Smith R H. 1959. The development of function of the rumen in milk fed calves. *Journal of Agricultural Science* **52**: 72–78.

Snedecor G W and Cochran W G. 1968 *Statistical Methods*. 8th edn. Iowa State University Press, Iowa, USA.

Topps J H. 1992. Potential, composition and use of legume shrubs and trees as fodder for livestock in the tropics. *Journal of Agricultural Sciences* (Cambridge) **118**: 1–8.

Van Soest P J, Robertson J B and Lewis B A. 1991. Methods for dietary fiber, neutral detergent fiber and non starch polysaccharides in relation to animal nutrition. *Journal of Dairy Science* **74**: 3588–97.

Woodward A and Reed J D.1989. The influence of polyphenolics on the nutritive value of browse: a summary of research conducted at ILCA. *ILCA Bulletin* **35**: 2–11.