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Nutrient intake, utilization and growth performance of Jalauni lambs and Bundelkhandi kids grazed on *Hardwickia binata* (anjan) based silvipasture

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Abstract
Comparative nutrient utilization and growth performance were studied on 25 each of Jalauni lambs and Bundelkhandi kids under grazing on *H. binata* based silvipasture during growing (August-October) as well as post growing (November-January) seasons along with supplementation (1% of body weight) of concentrate mixture. The pasture crude protein content was reduced from 8.37% to 6.81% whereas NDF content was increased from 71.0% to 74.8% with advancement of maturity of pastures from September to December. DM intake of lambs and kids was comparable in both the seasons. DM, OM and NDF digestibility were comparable in both the species having no seasonal variation, however, CP digestibility of ingested forage was higher ($P<0.05$) in the growing season than post-growing season. DCP intake (g/kg$W^{0.75}$) was higher (5.39 vs 5.34) in September in both the species as compared to December (3.66 vs 3.94). ME intake (MJ/d) was similar in both the species and significantly ($P<0.05$) higher during post growing season as compared to growing season, however, ME intake (MJ/kg$W^{0.75}$) was comparable between the species and seasons. Daily live weight gain was comparable between the species, however, both the species showed significant difference in daily gain for growing and non-growing season. It was concluded that nutrient utilization and growth performance were comparable between lambs and kids, however, digestibility of CP was reduced significantly ($P<0.05$) during non-growing season in both the species.

Keywords: Bundelkhandi kids, Growth performance, *Jalauni* lambs, Nutrient utilization, Silvipasture

Abbreviations: **ADF**: Acid detergent fiber; **ADICP:** Acid detergent insoluble CP; **CP**: Crude protein; **IP**: Insoluble protein; **NDF**: Neutral detergent fiber; **NDICP**: Neutral detergent insoluble CP; **NPN**: Non protein nitrogen; **OM**: Organic matter; **SP:** Soluble protein; **TP**: True protein

Introduction

Silvipasture system is an efficient and integrated land use management system of tree species, fodder and or livestock simultaneously on the same unit of land which results in an increase of overall production. This system is well suited for rearing domesticated animals, particularly small ruminants. Goats and sheep play a significant role in the subsistence economy of farmers in the country. Goats and sheep are multipurpose animals which provide hair, wool, meat, milk and skin. The production of meat from goats and sheep play a vital role in the supply of animal protein for the people. Small ruminant production in village systems in tropical countries is often characterized by poor growth rates and high mortality (Suresh and Chaudhary, 2015). The productivity of small ruminants can be improved by improving the nutrition either through concentrate feeding or provision of additional forage (Salem, 2010). Although the potential of silvipastural systems in enhancing fodder production is widely known but there is a paucity of information on nutritional aspects of animals foraging on developed silvipastures. The objectives of the present experiment were to assess seasonal variations in the intake and nutrient utilization and growth performance of small ruminants grazed in a *Hardiwickia binata* based silvipasture.

Materials and Methods

Experimental design: The study was conducted on 9-10 months aged growing lambs and kids. Twenty five each of Jalauni lambs (average body weight 17.87±0.58 kg) and Bundelkhandi kids (average body weight 16.99±0.38 kg) were allowed to graze on 2.33 ha (stocking rate of 2 ACU/ha) of *Hardiwickia binata* tree and grass (*Cenchrus ciliaris, Crysopogon fulvus, Panicum maximum and Stylosanthes hamata*) based silvipasture during growing (August-October) as well as post growing (November-January) seasons at Central Research Farm, ICAR-Indian Grassland and Fodder Research Institute, Jhansi. The yearly forage production potential of the silvipasture

system from ground and above ground vegetations were estimated as per the procedure described by Prajapati (1980).

The animals were allowed to graze for 7 hours daily from 9 am to 4 pm in 5 years old synthesized (2 tier) silvipasture comprising of *Stylosanthes hamata*, *Cenchrus ciliaris*, *Panicum maximum*, *Crysopogon fulvus* (one tier) and *Hardwickia binata (another tier)*. All the animals were also supplemented with concentrate mixture (consisted of barley, mustard cake, wheat bran, mineral mixture and common salt; 40: 30: 27: 2: 1) @ 1.0% of their body weight at stall after grazing. Body weights of animals were recorded fortnightly. After 50 days of experimental grazing, digestion trial of 7 day duration was conducted in the month of September and December on 6 animals each from lambs and kids following lignin as internal marker (Sankhyan *et al.,* 1999). Total faeces voided for 24 hrs were collected using faeces collection bags (Sankhyan *et al.,* 1999).

Botanical composition of the diet: A direct observation and simulation method was used to determine the botanical composition of the diet consumed by the animals. Samples of the ingested species that were being taken by the animals were hand clipped for three consecutive days. The individual animals were observed and forage samples were collected for the entire grazing period from 9 am to 4 pm.

Analysis of samples and data: The representative samples of feeds and faeces collected during digestion trial were analyzed for dry matter (DM), ash and ether extract according to AOAC (1995). Samples were also analyzed for neutral detergent fiber (NDF), acid detergent fiber (ADF) and lignin (Goering and Van Soest, 1970). Total nitrogen was determined by micro-kjeldhal method (AOAC 1995). Acid detergent insoluble nitrogen (NDIN), non protein nitrogen and soluble protein were estimated as per Licitra *et al*. (1996). Protein fractions were calculated using the equations of Sniffen *et al*. (1992). Mean data were compared for breeds and also compared over different seasons for statistical differences using Student's t-test (Snedecor and Cochran, 1989).

Results and Discussion

***Meteorological conditions and biomass yield*:** Growing season from August to September was the main season of the vegetative growth with high rainfall (585.6 mm), and non-growing season from November to January, was the moderate vegetative growth season with rain only in the form of little winter showers (78.0 mm). The mean biomass yield from pasture was 6.42 ton DM/ha and pruned foliage yield as top feed was 0.63 ton DM/ha. Thus, the total yield was 7.05 ton DM/ha, which was almost similar (7.76 ton/ha) to silvipasture system comprising of *C. ciliaris* as ground cover, *D. cinerea* as bush and *L. leucocephala* as tree (Rai and Rai, 2010). Ram *et al.* (2016) also recorded a similar biomass yield in *H. binata* based silvipastures of different grasses and legumes under semiarid climatic conditions of Bundelkhand region.

***Chemical composition of pasture biomass*:** Chemical composition of pasture forages indicated that DM content varied from 33 to 42% (Table 1). OM and ash contents in all the feeds were more or less similar. Leguminous component of pasture like *S. hamata* and *H. binata* had higher CP values while range grasses had lower and similar CP content. Feeds of leguminous origin had lower NDF contents than range grasses. CP and NDF content of guinea grass were similar to earlier report of Das *et al*. (2015). Singh and Singh (2017) however, reported lower CP content in *C. ciliaris* (5.35%), *C. fuvus* (3.60 %) and in *H. binata* (7.80%) than the present findings which might be due to different stage of harvesting of plant samples. Higher lignin content was reported in *H. binata* in earlier study (Singh *et al*., 2016). Average crude protein content of pasture biomass was 8.37% in September and reduced to 6.81% in December whereas, neutral detergent fiber content increased from 71.0 to 74.8%. The CP content of pasture was similar as reported by Raghuvanshi *et al*. (2007). However, Sun *et al. (*2014) reported much higher reduction in crude protein content and increase in fiber content during post growing season which might be due to advance stage of maturity and moisture stress in contrast to present study where the rainfall continued for the whole study period and delayed the maturity of the herbage biomass. Average lignin content of the pasture biomass also increased from 6.45% in September to 8.42% in December. The chemical composition of pasture is influenced by season, type of soil, stocking density, type grazing pasture and climate (Mahala *et al.,* 2009; Subhalakshmi *et al*., 2011). Similar change in nutrient composition was also reported in semi-arid pasture (Das *et al*., 2011). During monsoon most of the pasture components were in pre-flowering/full bloom, stage, during which the nutrient concentration was maximum. The buffer soluble protein fraction was highest in *S. hamata* (29.65%) and lowest in *C. ciliaris* (19.60%; Table 2) and corroborated with the

findings of Gupta *et al*. (2011), however, Chaurasia *et al*. (2006) reported higher soluble protein values in *H. binata* (50.39%) and *C. ciliaris* (31.45%). The NPN%SP was highest in guinea grass (71.10%) and lowest in *S. hamata (*43.52*%)*. Similar NPN values were reported earlier in grasses by Das *et al.(*2015). ADIP%CP ranged from 23.9% (*S. hamata*) to 42.72% (*H. binata*), whereas NDIP%CP varied from 71.2% (*H. binata*) to 49.82% (guinea grass). Similar ADIP%CP values were also recorded earlier in grasses (Das *et al*., 2015). The higher NDIP%CP value in *H. binata* might be due to higher lignin content in cell wall. The concentrations of nitrogen fraction like P_A and P_{B1} was almost similar in all the components of pasture except *S. hamata* which recorded higher value for P_{B1} (Table 3). The fraction P_{B2} content was higher in guinea grass whereas P_{B3} value was higher in *S. hamata*. Fraction P_{B3} (slowly degraded true protein) is insoluble in neutral detergent but soluble in acid detergent (NDIP minus ADIP). The fraction P_{B2} and P_{B3} are degraded in the rumen to a lesser extent than P_A and P_{B1}indicating that these feeds have more bypass protein. The P_C fraction is that fraction of feed CP which cannot be degraded by both ruminal microbes and the animal itself and thus have no feeding value. This fraction appears to be essentially indigestible and poorly used by the ruminants (Rebole *et al.,* 2001).This PC fraction mostly consist of N bound to lignin. P_C content was higher in *H. binata* (42.72%) than other plant species which was supported by higher content of lignin in the cell wall.

Nutrient intake and digestibility: The forages that were selected by small ruminants under the trial primarily consisted of *C. ciliaris, C. fulvus, P. maximum, S. hamata and H. binata.* DM intake of lambs and kids was compa

Table 1. Chemical composition (% DM basis) of pasture forages

Attributes	DM	CP	NDF	ADF	ADL	Ash
C. fulvus	35.04	7.36	77.70	44.98	5.91	5.59
P. maximum	33.67	8.60	76.54	45.64	5.00	8.24
S. hamata	33.02	11.12	55.35	40.97	7.79	6.82
C. ciliaris	37.17	8.45	74.06	48.91	6.02	6.88
H. binata	42.46	10.45	51.81	35.58	14.64	10.12

DM=Dry matter, CP=Crude Protein, NDF=Neutral detergent fiber, ADF=Acid detergent fiber, ADL=Acid detergent lignin

Table 2. Primary protein fractions (% DM) of pasture forage species

Attributes	*C. fulvus*	*P. maximum*	*S. hamata*	*C. ciliaris*	*H. binata*
NDICP%CP	58.57	49.82	58.00	62.94	71.20
ADICP%CP	39.26	32.81	23.90	31.14	42.72
TP	6.26	7.34	9.68	7.52	9.04
NPN	1.09	1.25	1.44	0.92	1.40
SP%CP	23.41	20.52	29.65	19.60	22.78
NPN%SP	63.82	71.10	43.52	55.84	58.96

NDICP=Neutral detergent insoluble CP, ADICP=Acid detergent insoluble CP, TP=True protein, NPN=Non protein nitrogen, SP=Soluble protein, IP=Insoluble protein

Table 3. Nitrogen fractions (%CP) of experimental forage species

Attributes	P_A	P_{B1}	P_{B2}	P_{B3}	P_C
C. fulvus	14.94^{d}	8.46^{b}	18.01^{d}	19.31^{b}	39.27^{d}
P. maximum	14.59^{d}	5.93^{a}	29.66^{e}	17.01^{a}	32.81^{c}
S. hamata	12.90^{b}	16.74^{d}	12.34^{b}	34.10^{e}	23.90^{a}
C. ciliaris	10.94^{a}	8.65^{b}	17.45^{c}	31.80^{d}	31.14^{b}
H. binata	13.43^{c}	9.34^{c}	6.02^{a}	28.47^{c}	42.72^{e}

P_A (soluble protein); P_{B1} (rapidly degradable protein); P_{B2} (intermediately degradable protein); P_{B3}(slowly degradable protein); P_C (unavailable protein)

Means bearing different superscripts in the same column differed significantly ($P<0.05$)

-rable in both the seasons (Table 4). Similarly Kabir *et al*. (2004) also observed no difference in DM intake in sheep and goat grazed with protein supplementation. The DM intake values in goats were in agreement with earlier report of Bhatta *et al*. (2002). In the present study, DM intake was comparable in both the species and it increased significantly (P<0.05) by 10.43% in kids and 6.72% in lambs from growing to non-growing season. Shinde *et al*. (2001) observed that goats consumed 64·0, 54·0 and 55·9 g DM/kgW$^{0.75}$/day, in monsoon, winter and summer seasons. DM, OM and NDF digestibility were comparable in both the species having no seasonal variation and similar observation was also report by Bhatta *et al*.(2004) in sheep. No differences between sheep and goats were also recorded in nutrient digestibility by Alcidae *et al.* (2000) and Ranilla *et al*. (2005) and they suggest that no differences in digestibility might be due to availability of good quality feeds/diets. CP digestibility of ingested forage was higher (P<0.05) in the growing season than non-growing season. DCP intake (g/kgW $^{0.75}$) was higher (5.39 vs 5.34) in September in both the species as compared to December (3.66 vs 3.94), which might be due to decreased in protein content of available pastures. N intake per kg DOM intake was 29.48 in kids and 29.29 in lambs during September, which indicated that the N intake was sufficient for the efficient utilization of energy by the rumen microbes and its optimum growth. ME (MJ/d) was similar in both the species and significantly higher (P<0.05) during post growing season as compared to growing season, however, ME (MJ/ kgW $^{0.75}$) was comparable between the species and seasons. Nutritive value in terms of DCP was comparable in both the species and significantly (P<0.05) lower during post growing season as compared to growing season. However, the nutrient density in terms of TDN or ME did not exhibit any seasonal difference. The quality and quantity of tropical herbage is known to decline markedly after rainy season during onset of winter and causes major constraint for small ruminant production, however, the results of the study showed that *H. binata* based silvipasture system could provide fairly high levels of energy to small ruminants without significant seasonal fluctuations.

Table 4. Nutrient utilization and growth performance of Jalauni lambs and Bundelkhandi kids grazed on *H. binata* based silvipasture system

Attributes	Season/Breed				SE
	Growing		Post growing		
	Jalauni	Bundelkhandi	Jalauni	Bundelkhandi	
DMI (kg/d)	0. 778^{a}	0.725^{a}	0. 923^{b}	0.899^{b}	0.10
DMI (g/kgW$^{0.75}$)	85.60	81.36	91.36	89.85	2.28
DCP intake (g/d)	48.99^{b}	47.67^{b}	36.99^{a}	39.46^{a}	1.87
DCPI (g/kgW$^{0.75}$)	5.39^{b}	5.35^{b}	3.66^{a}	3.94^{a}	0.40
DOMI (kg/d)	0.48^{a}	0.46^{a}	0.56^{b}	0.57^{b}	0.02
DOMI(g/kgW$^{0.75}$)	52.86	51.52	55.78	56.87	1.47
N intake (g/kg DOMI)	29.48^{b}	29.29^{b}	24.17^{a}	24.90^{a}	0.77
ME (MJ/d)	7.48^{a}	7.19^{a}	8.78^{b}	8.91^{b}	0.21
ME (MJ/W $^{0.75}$)	0.82	0.81	0.87	0.89	0.23
Digestibility coefficient (%)					
DM	64.40	66.70	64.12	66.89	0.64
OM	67.39	69.09	66.48	68.85	0.55
CP	55.57^{b}	56.70^{b}	43.46^{a}	45.78^{a}	1.98
EE	73.21	74.23	71.79	73.55	0.57
NDF	61.85	63.38	62.42	64.58	0.72
ADF	56.47	56.92	57.67	57.98	0.57
NFE	65.40^{p}	69.68^{q}	66.25	68.99	0.87
Nutritive value (%)					
DCP	6.32^{b}	6.56^{b}	4.03^{a}	4.38^{a}	0.40
TDN	63.88	65.81	63.17	65.73	0.57
ME (MJ/kg)	9.62	9.91	9.51	9.90	0.08
Daily gain (g/d)	53.90^{b}	48.92^{b}	40.50^{a}	38.52^{a}	0.82

^{a,b}Means bearing different superscripts in each species class indicate difference(P<0.05) due to season

^{p,q} Means bearing different superscripts in each season indicate difference(P<0.05) due to species

Daily live weight gain was comparable for both the species, however, both the species showed significant difference in daily gain during growing and non-growing season. Similar values (54.02 g/d) for daily gain in goats/ kids under grazing with supplementation was also observed earlier (Das *et al.,* 2012). Similarly, Rai and Rai (2010) reported a daily gain of 54 g in Muzaffarnagari lambs grazed under silvipasture system.

Conclusion

It was concluded that nutrient utilization and growth performance were comparable between lambs and kids, however, digestibility of CP was reduced significantly ($P<0.05$) during non-growing season in both the species. *H. binata* based (2 tier) silvipastures also indicated great potentials in rearing of kids and lambs for sustainable production.

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