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Does Feeder Type Influence the Performance of Stable and Mixed Bucks in Stall Fed System?

Research Article

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ABSTRACT

Present investigation was conducted to assess the effect of two feeder types (hexagonal *vs.* linear) on performance of stable (before mixing) and mixed Beetal bucks. In first trial, stable bucks were studied for 4-week period at hexagonal (B_H) *vs.* linear (B_L) feeder (n=6 each). In second trial, after rearing 4 weeks on two feeder types, half (3) of the bucks {1 high, 1 intermediate and 1 low ranked in social hierarchy} from both the groups were interchanged to form two mixed groups (hexagonal and linear mixed bucks i.e. B_{HM} and B_{LM}), which were observed for 2 weeks period. Bucks were observed for weight gain, body condition score (BCS), daily feed intake, feed wastage, injuries and blood biochemical parameters. Blood samples were collected at weekly interval before regrouping period and at day 1 (regrouping), 3, 7 and 14 after regrouping. Body weight (BW) and dimensions of adult bucks had no influence of feeder type during premixing as well as post-mixing. Feed intake as well as wastage (green fodder) too did not differ statistically though overall feed wastage was numerically higher at hexagonal feeder. Injuries and lameness incidences were relatively more at hexagonal feeder ($B_H : B_L$ :: 1 : 0 and $B_{HM} : B_{LM}$ :: 3 : 1). Blood biochemical indicators of stress did not differ between the groups. Stable and regrouped Beetal bucks had similar performance indicators at both types of feeders with minor welfare advantages at linear feeder.

KEY WORDS beetal, feeder, mixing, wastage, welfare.

INTRODUCTION

India has second largest goat population (148.88 million) in the world and Beetal is a pride dual purpose (meat and milk) breed of Punjab state of India making it a leading state in average goat milk (1.42 kg/d) productivity (BAHFS, 2019). In modern production systems, regrouping (mixing) and manipulations during critical periods (kidding, weaning) are integral parts of farm management (Miranda-de La Lama and Mattiello, 2010). Many stressors are inescapable for captive animals and pose greater risk (Morgan and Tromborg, 2007). Monitoring of feeding activities in confinement and its potential influence on performance of animals is gaining importance (Keil *et al.* 2017; Neave *et al.* 2018; Silva *et al.* 2018; Goetsch, 2019; Kaur *et al.* 2021). Feeding management specific to the needs of animals may help in reducing conflicts and preventing injuries (Noack and Hauser, 2004; Waiblinger *et al.* 2010; Tuncer *et al.* 2016). As goats remain in frequent contact with the feeder, it may pose risk of injuries if poorly designed (Kielland *et al.* 2010). Design of feeders have direct implications on performance of any farm in terms of feed wastage, feed intake, aggression (injuries) and stress in group mates.

Further, mixing of unfamiliar goats in groups or regrouping is inevitable at livestock farms at various occasions. Regrouping with unfamiliar animals has negative consequence on goat welfare (Millman and Duncan, 2001). Negative effect of introductions of non-familiar animals in groups has been noted in several studies and species [goats (Slavnitsch, 2008; Szabo, 2011), cattle (Hasegawa *et al.* 1997; Phillips and Rind, 2001; O'Driscoll *et al.* 2006; Von Keyserlingk *et al.* 2008), pigs (Hyun *et al.* 1998)]. Most of these studies included mixing of diverse groups such as young *vs.* old, uniparous *vs.* multiparous animals. It may lead to short-term (injuries) and long-term (exclusion from food or mating partners) negative effects. The continuous social stress may even alter the immune responses of the animals and, thus, make them prone to diseases (Pakhretia and Pirta, 2010). Bucks are usually more aggressive than does. Mixing of bucks of similar age or physiological status in groups has not been investigated earlier.

Different designs of goat feeders are used across the globe depending upon availability of local materials, feed resources, feeding practices etc. Hexagonal feeder is conventionally being used for feeding of goats in many organized goat farms alongside frequent usage of linear feeder as well. Keeping in view above facts, this study was conducted to assess the effect of two feeder types (hexagonal vs. linear) on performance of stable group of Beetal bucks as well as on the regrouped (mixed) bucks. Hypothesis is to know if two feeder types have influence on feed intake (thus performance) of regrouped bucks.

MATERIALS AND METHODS

Location of research

The present study was conducted in October-November, 2018 at Goat Research Farm, Guru Angad Dev Veterinary and Animal Sciences University (GADVASU), Ludhiana, Punjab (India). The geographical position of experimental area was as follows: Latitude of 30˚ 90 North, Longitude of 75˚ 80 East and at the height of 246 meters above the mean sea level. Experiment coincided with onset of winter season. The research plan (Proposal No: GADVASU/2018/IAEC/44/04) was approved by the Institutional Animal Ethics Committee (IAEC) of GADVASU, Ludhiana vide memo no: IAEC/2018/1025-1060 dated: May 03, 2018.

Experimental bucks and their management

A total of 12 Beetal bucks were used in the experiment. The bucks were divided into two treatment groups i.e. Hexagonal (B_H) and Linear (L_H) feeder groups (n=6 each), with similar covered (2 m^2/buck) and open area (4 m^2/buck). Each of the two treatment groups based on feeder types (Mean±S.E. of BW and age 55.80±3.91 *vs.* 56.63±5.25 kg and 855.33±46.84 *vs.* 875.00±35.83 days respectively at hexagonal *vs.* linear feeder) included one horned and five hornless (disbudded at early age) bucks. Animals in each group were de-wormed and vaccinated before the start of experiment, as per schedule, in order to maintain uniform health status.

Feed ingredients used for concentrate feed were maize, soybean meal, wheat bran, deoiled rice bran, mineral mixture and common salt with chemical composition as follows: 94% dry matter, 20.34% crude protein, 4.64% ether extract, 35.2% neutral detergent fiber, 14.3% acid detergent fiber and 10.65% ash. Chaffed green fodder included maize and pearl millet as per recommendations of the Goat Research Farm of institute. Concentrate feed (@500 gm/head) was offered once in the morning (9:00 a.m.) while green fodder (@5 kg/head) twice (11:00 a.m. and 4:00 p.m.) during the day. Chaffed maize and pearl millet (bajra) were offered as green fodder. Round the clock potable water was available for the goats.

Methodology

All the experimental bucks had earlier experience of group feeding using hexagonal feeder during early growing stage and using linear feeder during later stages. However, two weeks before start of trial, they were grouped as per treatments and fed using large metallic tubs during the adaptation period. Thereafter two trials (stable group i.e. before mixing, and mixed group i.e. after mixing) were conducted with respect to two feeder types as per description given below:

A total of 12 Beetal bucks were divided into two treatment groups (n=6 each) based on type of feeders used i.e. bucks on hexagonal feeder (B_H) and linear feeder (B_L) (Figures 1a and 1b). They were placed in two separate pens with provision of either linear feeder (height: 53 cm, width: 45 cm and depth: 10 cm) or hexagonal feeder (height: 55 cm, radius: 44 cm and depth: 11 cm) and rest of the conditions were kept uniform. Feeder space per buck (≈ 50 cm/buck) was almost similar in both the groups as length of linear feeder was 285 cm and circumference of one hexagonal feeder was 290 cm. Their relative performance and interactions were studied for a period of 4 weeks before mixing or regrouping.

In an attempt to do homologous regrouping after completion of above trial, 3 bucks (1 high, 1 intermediate and 1 low ranked in social hierarchy) from each group or pen were interchanged (mixed). Ranks in social hierarchy were determined based on index of success (Miranda-de la Lama *et al.* 2011) during 4-week pre-mixing period. Mixed groups were checked for no statistical difference with respect to the study parameters at the time of mixing. Now, these new treatment groups were designated as hexagonal mixed bucks (B_{HM}) and linear mixed bucks (B_{LM}). Relative performance of these mixed bucks was studied for a period of 2 weeks after regrouping.

Observations recorded

Body weight was recorded at weekly interval using framed electronic balance with precision up to 10 grams. Body condition score (BCS) of the experimental animals was recorded weekly by the visual-cum-palpation method. Nine-point scale was used for body condition scoring i.e. 1 to 5 scale with increments of 0.5 point. After proper assessment of the animal's body and its frame it was assigned with its BCS (Sharma *et al.* 2018).

Daily feed intake of each group was estimated by calculating the difference between offered quantities of concentrate and green fodder from residual (leftover in feeder) and waste (fallen on the ground) feed. Residual quantity of feed was collected from respective feeders after completion of feeding and weighed twice daily i.e. in the morning for concentrate and in the evening for green fodder. Waste or fallen feed was collected carefully from the ground using thin metal plates avoiding faeces and weighed in the morning for concentrate and in the evening for green fodder. For concentrate, both residual and waste (fallen) quantity was negligible throughout the study.

During the experiment, the animals were daily observed for their health status. Ailments were recorded and classified as per experimental group for interpretation of results. However, frequencies of ailments or diseases were not sufficient to be utilized for statistical analysis.

Blood samples were collected from the jugular vein into heparinized tubes and EDTA coated vials from eight bucks (n=4 from each group) for separation of plasma and hemolysate (Andersen *et al.* 2008). Samples were collected on 1^{st}, 14^{th} and 28^{th} day in stable bucks and on 1^{st}, 3^{rd}, 7^{th} and 14^{th} day in regrouped bucks. However, due to financial constraints all the samples were not tested for all parameters as indicated in the tables. For separation of plasma, blood samples collected were first centrifuged in refrigerated centrifuge (Heraeus BIOFUGE STRATOS; Thermo Electron Corporation) at 3000 rpm for 15 minutes. The upper layer (plasma) was removed and stored at -20 ˚C until estimation of different biochemical parameters and the remaining erythrocyte pellet was washed and centrifuged thrice with normal saline solution for hemolysate preparation. The hemolysate was prepared by adding distilled water slowly up to the initial marked level with constant stirring. The hemolysate was quickly stored in aliquots at -20 ˚C till analyzed for MDA level and various antioxidant enzymes. Various blood biochemical tests (stress indicators in animals) performed to assess the level of stress in the experimental animals kept at different feeders types, before and after regrouping. These included estimation of plasma cortisol concentration using ELISA technique, total protein, albumin, superoxide dismutase (SOD), catalase (CAT), glutathione reductase and total immunoglobulin as per standard techniques.

Statistical analysis

Collected data were arranged and analyzed using standard statistical methods with SPSS 20.0 software. Two treatment groups were compared using one way analysis of variance (ANOVA) for all the parameters except for blood parameters (two-way ANOVA to assess the effect of feeder and days/time after mixing on blood parameters) using Tukey's HSD test and results were presented as mean ± standard error. Results were interpreted using significance levels up to 5% for bucks fed on hexagonal and linear feeder.

RESULTS AND DISCUSSION

Body weight and BCS of Beetal bucks fed on hexagonal vs. linear feeder had no statistical difference during successive weeks (Table 1) in stable (B_H *vs.* B_L) and regrouped bucks (B_{HM} *vs.* B_{LM}).

Bucks were offered concentrate feed mixture and chaffed green fodder (maize and pearl millet). However, bucks consumed offered concentrate feed completely at both types of feeders and residue/wastage was too scanty to be measured indicating higher preference for concentrate feed. Average daily feed intake and wastage (green fodder) values at hexagonal *vs.* linear feeder in stable and regrouped bucks during successive weeks were statistically indifferent (Table 2). The daily wastage of green fodder (%) shows nearly similar pattern at both types of feeders on day-to-day basis (Figure 2).

Wastage values were higher during first two weeks and later (till regrouping) values were relatively lower which may be indicative of habituation at feeders. Whereas, wastage of green fodder again increased after regrouping in both the groups and it remained higher during first week after regrouping. Overall green fodder wastage was more in hexagonal feeder (184.43 kg) compared to the linear feeder (176.38 kg) for feeding of 6 Beetal bucks during total 6 weeks period.

Table 1 Body weight and BCS of stable and regrouped Beetal bucks fed on hexagonal *vs*. linear feeder (Mean±SE)

Parameter	Period	B_H	B_L	P-value
Stable bucks				
Body weight (kg)	Initial	55.80±3.91	56.63±5.25	0.90
	7th day	56.83±3.76	57.10±5.34	0.97
	14th day	57.97±3.44	58.77±5.31	0.90
	21st day	57.10±3.58	59.10±5.17	0.76
	28th day	55.66±3.26	58.00±5.24	0.71
BCS	Initial	2.21±0.08	2.21±0.15	1.00
	7th day	2.33±0.12	2.29±0.12	0.81
	14th day	2.58±0.05	2.46±0.08	0.21
	21st day	2.33±0.08	2.33±0.12	1.00
	28th day	2.42±0.05	2.33±0.08	0.42
Regrouped bucks				
Parameter	Period	B_{HM}	B_{LM}	P-value
Body weight (kg)	Initial	57.03±4.77	56.63±3.98	0.95
	7th day	56.00±4.72	56.60±3.88	0.92
	14th day	56.93±4.79	55.60±3.70	0.83
BCS	Initial	2.29±0.10	2.42±0.05	0.41
	7th day	2.33±0.12	2.42±0.11	0.58
	14th day	2.25±0.09	2.37±0.14	0.41

B_H: bucks on hexagonal feeder; B_L: bucks on linear feeder; B_{HM}: hexagonal mixed bucks; B_{LM}: linear mixed bucks and BCS: body condition score.

Table 2 Feed intake and wastage at hexagonal *vs*. linear feeder for stable and regrouped Beetal bucks (Mean±SE)

Parameter	Period	B_H	B_L
Stable bucks			
Daily green fodder intake (on fresh basis in kg)	Week 1	22.34±1.86	22.18±1.70
	Week 2	21.24±1.51	22.84±0.12
	Week 3	24.97±0.79	24.33±0.94
	Week 4	28.57±0.28	28.91±0.43
Daily dry matter intake (kg)	Week 1	10.19±0.61	10.14±0.56
	Week 2	9.83±0.50	10.36±0.34
	Week 3	11.06±0.26	10.85±0.31
	Week 4	12.25±0.09	12.36±0.14
Daily green fodder wastage {kg (%)}	Week 1	7.66±1.86 (25.53±6.20)	7.43±1.62 (24.77±5.39)
	Week 2	8.76±1.51 (29.20±5.04)	6.81±0.97 (22.69±3.23)
	Week 3	5.03±0.79 (16.77±2.64)	5.38±0.88 (17.95±2.96)
	Week 4	1.43±0.28 (4.78±0.92)	1.04±0.41 (3.46±1.37)
Total green fodder wastage (on fresh basis in kg)	In 4 weeks	160.20	144.64
Regrouped bucks			
Parameter	Period	B_{HM}	B_{LM}
Daily green fodder intake (on fresh basis in kg)	Week 1	27.65±0.54	27.02±0.31
	Week 2	28.88±0.27	28.21±0.47
Daily dry matter intake (kg)	Week 1	11.94±0.18	11.73±0.20
	Week 2	12.35±0.09	12.13±0.16
Daily green fodder wastage {kg (%)}	Week 1	2.35±0.54 (7.83±1.80)	2.83±0.58 (9.42±1.93)
	Week 2	1.11±0.27 (3.71±0.91)	1.71±0.45 (5.69±1.49)
Total green fodder wastage (on fresh basis in kg)	In 2 weeks	24.23	31.74
Overall green fodder wastage (on fresh basis in kg)	In 6 weeks	184.43	176.38

B_H: bucks on hexagonal feeder; B_L: bucks on linear feeder; B_{HM}: hexagonal mixed bucks and B_{LM}: linear mixed bucks.

The summary of feed utilization in stable and regrouped Beetal bucks fed at hexagonal vs. linear feeder shows marginal differences (Table 3). It is evident that average dry matter requirement (g/kg BW) was numerically more during most of the weeks in the hexagonal fed bucks than linear fed bucks.

However, due to lack of replicates it cannot be fully validated that maintenance of Beetal bucks was more efficient at linear feeder. Results showed relatively more ailments in regrouped bucks despite the fact that post-regrouping observation period (14 days) was shorter than pre-regrouping period (28 days) (Table 4).

1(a) 1(b)

Figure 1 Beetal bucks feeding at Hexagonal and Linear feeder

Table 3 Summary of feed utilization in Beetal bucks on hexagonal *vs.* linear feeder (Mean±SE)

Weeks	Total DMI (B_H) (kg/week/pen)	Total DMI (B_L) (kg/week/pen)	Total body weight (B_H) (kg/pen)	Total body weight (B_L) (kg/pen)	DM requirement (B_H) (g/kg BW basis)	DM requirement (B_L) (g/kg BW basis)
Week 1	71.34	62.81	341.00	342.60	29.89	26.19
Week 2	68.80	72.49	347.80	352.60	28.26	29.37
Week 3	77.41	75.94	342.60	354.60	32.28	30.59
Week 4	85.72	86.51	334.00	348.00	36.67	35.51
Regrouped bucks						
	B_{HM}	B_{LM}	B_{HM}	B_{LM}	B_{HM}	B_{LM}
Week 1	83.61	82.16	336.00	339.60	35.55	34.56
Week 2	86.46	84.88	341.60	333.60	36.16	36.35

B_H: bucks on hexagonal feeder; B_L: bucks on linear feeder; B_{HM}: hexagonal mixed bucks and B_{LM}: linear mixed bucks.
DM: dry matter and DMI: dry matter intake.

Table 4 List of ailments in stable and regrouped Beetal bucks at hexagonal *vs.* linear feeder

Group	Type of ailment	Stage of experiment
Stable bucks		
Hexagonal (B_H)	Lameness	4^{th} week
Regrouped bucks		
Hexagonal mixed (B_{HM})	Head/horn injury	Day of mixing
Hexagonal mixed (B_{HM})	Head/horn injury	2^{nd} day post mixing
Hexagonal mixed (B_{HM})	Lameness	First week post mixing
Linear mixed (B_{LM})	Lameness	First week post mixing
Hexagonal mixed (B_{HM})	Alopecia (tail)	First week post mixing
Linear mixed (B_{LM})	Alopecia (patches)	Second week post mixing

B_H: bucks on hexagonal feeder; B_L: bucks on linear feeder; B_{HM}: hexagonal mixed bucks and B_{LM}: linear mixed bucks.

Ailments related to agonistic encounters among the animals i.e. injuries/lameness were more common in hexagonal feeder group. Ratio of such ailments was 1 : 0 and 3 : 1 in hexagonal and linear fed bucks before and after regrouping respectively.

Blood parameters of stable and regrouped Beetal bucks fed at hexagonal vs. linear feeder shows minor differences between groups (Table 5).

All the blood biochemical parameters remained statistically indifferent at two feeders except superoxide dismutase (SOD) which remained significantly ($P<0.01$) higher in B_H bucks on 1^{st} day at respective feeder. Key stress indicator i.e. plasma cortisol, remained numerically higher in concentration in B_H bucks at all stages with marginal significance on 28^{th} day ($P=0.06$). After regrouping, SOD level was higher ($P<0.05$) in B_{LM} bucks on 7^{th} day.

Table 5 Blood parameters of stable and regrouped Beetal bucks fed on hexagonal *vs*. linear feeder (Mean±SE)

Parameter	Stage	B_H (n=4)	B_L (n=4)	P-value
Stable bucks				
Protein (g/dL)	1st day	7.27±0.46	8.22±0.18	0.11
	14th day	7.36±0.57	7.47±0.09	0.86
	28th day	7.52±0.79	7.24±0.22	0.74
Albumin (g/dL)	1st day	2.83±0.08	3.32±0.28	0.14
	14th day	2.65±0.36	2.91±0.11	0.53
	28th day	3.04±0.38	2.93±0.17	0.80
Globulin (g/dL)	1st day	4.45±0.40	4.90±0.28	0.39
	14th day	4.71±4.20	4.56±0.19	0.75
	28th day	4.48±0.48	4.31±0.28	0.77
Cortisol (ng/mL)	1st day	152.31±32.85	82.35±18.72	0.11
	14th day	197.13±76.27	133.93±55.35	0.52
	28th day	179.41±46.24	72.35±8.69	0.06
Lipid peroxidase (nmol MDA produced/g Hb)	1st day	468.15±85.73	377.95±49.22	0.40
	28th day	456.45±17.75	430.60±17.05	0.33
SOD (units/mg Hb)	1st day	92.75±7.55[A]	46.25±9.25[B]	0.01
	28th day	55.50±10.68	32.50±4.50	0.09
Glutathione reductase (units/mL)	1st day	0.183±0.02	0.229±0.09	0.64
	28th day	0.106±0.03	0.153±0.03	0.30
Catalase (units/g Hb)	1st day	0.579±0.35	0.064±0.04	0.19
	28th day	0.107±0.04	0.089±0.03	0.73
Total Immunoglobulin (mg/mL)	1st day	2.18±1.22	6.70±3.14	0.23
	28th day	2.25±1.21	4.98±1.64	0.23
Regrouped bucks				
Parameter	Stage	B_{HM} (n=4)	B_{LM} (n=4)	P-value
Protein (g/dL)	#Initial	7.88±0.56	6.88±0.46	0.22
	1st day	7.49±0.24	7.46±0.12	0.93
	3rd day	7.91±0.21	7.54±0.29	0.34
	7th day	7.12±0.48	6.90±0.24	0.69
	14th day	7.47±0.38	7.18±0.17	0.51
Albumin (g/dL)	Initial	3.19±0.30	2.78±0.25	0.33
	1st day	3.02±0.17	3.17±0.20	0.59
	3rd day	3.08±0.16	3.16±0.11	0.68
	7th day	2.91±0.15	2.85±0.36	0.88
	14th day	3.08±0.28	2.99±0.34	0.85
Globulin (g/dL)	Initial	4.69±0.32	4.11±0.39	0.29
	1st day	4.46±0.21	4.29±0.32	0.67
	3rd day	4.83±0.18	4.37±0.32	0.26
	7th day	4.21±0.40	4.05±0.21	0.74
	14th day	4.39±0.23	4.19±0.25	0.57
Cortisol (ng/mL)	Initial	142.31±43.98	109.46±44.84	0.62
	1st day	149.63±75.58	112.83±38.30	0.68
	3rd day	108.32±32.78	102.10±39.78	0.57
	7th day	153.62±46.91	105.90±30.38	0.52
	14th day	102.44±32.84	98.88±38.12	0.67
Lipid peroxidase (nmol MDA produced/g Hb)	Initial	459.14±17.05	427.90±16.23	0.23
	1st day	550.28±40.94	536.09±33.26	0.79
	3rd day	545.68±46.99	495.75±42.69	0.46
	7th day	453.39±41.90	495.07±42.42	0.51
SOD (units/mg Hb)	Initial	41.65±11.65	46.28±9.26	0.77
	1st day	60.16±4.63	69.42±4.63	0.21
	3rd day	50.91±4.63	60.16±19.08	0.65
	7th day	32.39±4.63[B]	74.04±13.08[A]	0.02
Glutathione reductase (units/mL)	Initial	0.14±0.03[ab]	0.12±0.03	0.81
	1st day	0.13±0.03[ab]	0.08±0.03	0.29
	3rd day	0.21±0.05[a]	0.09±0.02	0.08
	7th day	0.05±0.01[b]	0.09±0.03	0.27
Catalase (units/g Hb)	Initial	0.07±0.03	0.13±0.03	0.24
	1st day	0.40±0.17	0.50±0.34	0.79
	3rd day	0.11±0.06	0.20±0.06	0.30
	7th day	0.57±0.48	0.07±0.03	0.34
Total immunoglobulin(mg/mL)	Initial	2.85±0.95	4.39±2.03	0.52
	1st day	4.76±1.30	7.40±2.92	0.44
	3rd day	4.14±0.89	5.95±2.21	0.48
	7th day	3.90±0.67	5.53±1.93	0.45
	14th day	3.43±0.49	4.23±1.61	0.65

B_H: bucks on hexagonal feeder; B_L: bucks on linear feeder; B_{HM}: hexagonal mixed bucks and B_{LM}: linear mixed bucks.
MDA: malonylaldehyde; SOD: superoxide dismutase and Hb: hemoglobin.
[A, B]: the means within the same row with different letter, are significantly different (P<0.05).
[a, b]: the means within the same column with different letter, are significantly different (P<0.05).

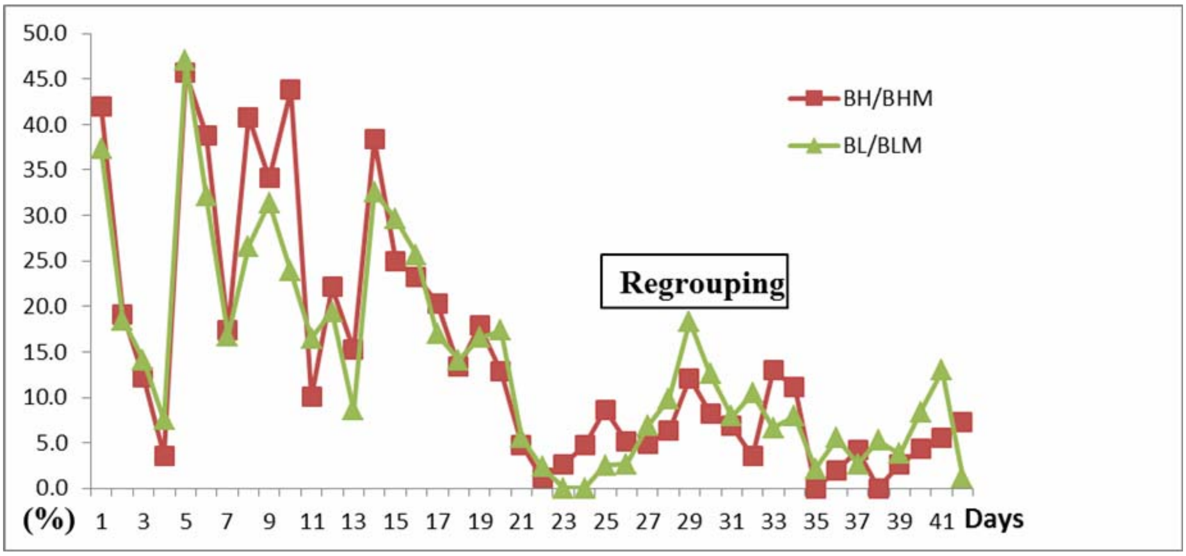

Figure 2 Daily green fodder wastage (%) at hexagonal *vs.* linear feeder in stable (1-28 days) and regrouped (29-42 days) bucks [B_H: bucks in hexagonal feeder; B_{HM}: hexagonal mixed bucks; B_L: bucks in linear feeder and B_{LM}: linear mixed bucks]

Plasma cortisol values remained numerically higher in hexagonal fed bucks at all stages after regrouping too. After regrouping, changes in most of the blood parameters of bucks were non-significant (except glutathione reductase in hexagonal fed bucks) indicating that bucks were physiologically less affected by mixing. Level of glutathione reductase was significantly higher on 3rd day after regrouping in hexagonal fed bucks.

Influence of feeder type on performance of group reared bucks could not be cited elsewhere. For group housing of bucks in general, studies are very scanty and individual rearing or smaller groups (Ángel-García *et al.* 2015) are usually recommended due to relatively higher aggression among themselves. Individual distance was shown to range from 0.1 m to 0.4 m in goats during feeding (Nordmann *et al.* 2015), however, the freely chosen distance could be even higher than 0.5 m (Aschwanden *et al.* 2008). Hence group size of six Beetal bucks per feeder was selected with nearly 0.5 m feeder space per buck in this study. Social environment of buck is comprised of sexual, competitive, aggressive interactions with parents, siblings, other conspecifics, or animals of different species, including humans (Katz, 1987) and are popularly known for high libido and sexual vigor (Fritz, 2017). Bucks have been less studied due to insatiable sexual appetite and lesser reproductive issues than does (Fritz, 2017).

The experiment utilized adult bucks of Beetal breed, which comes under medium to large sized goat breed category. Large sized goat breeds attain mature body weight later (30-42 months *vs.*18-24 months) than small sized breeds (Campbell and Marshall, 2016).

As experimental Beetal bucks had average age of 28-29 months i.e. these were closer to their mature body weight (having very slow growth rate) probability of visible influence of feeder type on body weight was less likely. Accordingly, no influence of feeder type on body weight and BCS in stable and regrouped bucks was noted during the experimental period. However, literature for comparison in this regard could not be cited.

Small ruminants are much more sensitive to feed particle size than cattle (ARC, 1980). Reducing the length of forage particles leads to increase in intake rate indicating more preference for the shorter material in goats (Kenney and Black, 1984). Chopping of fodder or browsing material enhances intake in goats (Omokanye *et al.* 2001; Kumari and Patel, 2015). In present study, Beetal bucks were offered chaffed maize and pearl millet (thick stemmed) based on seasonal availability at the farm. As goats prefer thin stemmed and leafy fodder over thick stemmed one, wastage values of green fodder seem to be relatively higher in present study on Beetal bucks. Lower wastage of concentrate feed was reported than green/dry fodder at various types of feeders i.e. lowest in rectangular (0.61%) followed by hexagonal (2.53%) and circular (4.3%) feeder (Upreti *et al.* 2005). However, in present study concentrate feed was consumed completely in all the observations and residue or wastage was too scanty to measure at both types of feeders.

Green forage wastage for stylo and napier were significantly lower in rectangular (7.74%, 13.86%) followed by chain barrel (17.3%, 19.5%), hexagonal (20.49%, 27.49%), hay rack (29.61%, 16.66%), and maximum for conventional *tatnu* (33.66%, 28.94%; locally designed) feeder in a study at Nepal (Upreti *et al.* 2005). Dry fodder wastage too had similar pattern in their study. These findings clearly indicate that wastage at rectangular and chain barrel feeders (both had linear dimensions) were lesser than hexagonal and circular feeders (round dimensions). In present study overall wastage was lower at linear feeder than hexagonal feeder but statistical differences were not found. Further, it is noteworthy to mention that the edges of linear feeder in present study were round and broad, making surface of the feeder shallower than hexagonal feeder which had relatively acute edges (Figures 1a and 1b) and it was very likely that wastage would have been much lower at linear feeder with similar type of edges. Wastage of feed increased after regrouping due to disturbance in social hierarchy leading to increased aggression and injuries as shown is present study. Reason for slightly higher wastage at hexagonal feeder could be due to relatively more instability while feeding as goats at hexagonal feeder have wider visual access to neighbouring goats (from both sides and front as well) leading to more competitiveness (instability) than at linear feeder (Kaur *et al.* 2021).

Increases in injuries after regrouping in group housed pigs have been noted in many studies (Barnett *et al.* 1992; O'Connell *et al.* 2003; Soede *et al.* 2006; Li *et al.* 2012). Soede *et al.* (2006) noted in groups of 4 prepubertal gilts (regrouped once a week for 6 weeks) and found that fighting increased in the groups that were mixed, resulting in an increase in skin lesions (Soede *et al.* 2006). Ison *et al.* (2014) also found that mixed gilts gained more (P<0.05) lesions on the front, middle, and ear body areas than control gilts during repeated mixing attempts (Ison *et al.* 2014). In goats, the occurrence of (visible) injuries was very low, with no injuries in young goats mixed with adult dry goats and three injuries (i.e. three animals) in young goats mixed with adult does (with kids) (Szabo, 2011; Szabò *et al.* 2013). In present investigation too injuries increased after regrouping in bucks, however, injuries were lesser at linear feeder. Literature regarding effect of feeder type with reference to injuries could not be cited for comparison. These findings suggest that regrouping is less harmful at linear feeder than hexagonal feeder for Beetal bucks. One of the most likely causes for relatively more harmful encounters at hexagonal feeder could be easy access to neighbouring goat's body parts by dominant one as animals stands at certain angle at the time of feeding than linear feeder where animals stand parallel to each other thus minimizing impact of bunting as well as risk of serious injuries especially to hind quarters. It is also supported by the earlier findings (Nordmann *et al.* 2015) that non-transparent head partitions can help in reducing social disturbances in goats.

Biochemical homeostasis plays an important role in animals to counteract stress. Stress stimulates the production of free radicals and reactive oxygen species detrimental to the animals (Tanaka *et al.* 2008).

The oxidative stress is a complex process (Ďuračková, 2007) and is the imbalance between oxidants and antioxidants in favor of the oxidants which are formed as a normal product of aerobic metabolism but during pathophysiological conditions can be produced at an elevated rate (Rahal *et al.* 2014). The clinical significance of biomarkers of oxidative stress in humans should be derived from a critical analysis of the markers and should give overall an index of redox or oxidative stress status in particular conditions (Marrocco *et al.* 2017).

Although there is very little information available about the oxidative stress parameters (superoxide dismutase (SOD), glutathione reductase, catalase (CAT) and malonylaldehyde (MDA)) in goats but still these parameters have been estimated as an indicative of stress profile of the animals. Elevated level of cortisol due to regrouping (mixing) have been noted in some species [goats (Andersen *et al.* 2008), pigs (Soede *et al.* 2006; Ison *et al.* 2014)]. As majority of blood biochemical parameters had no statistically significant difference among stable and regrouped bucks at both the feeders, it seems that feeder type did not have serious influence on physiological stress profile in goats.

CONCLUSION

It is concluded that stable and regrouped Beetal bucks had marginal welfare advantages at linear feeder with no difference in performance indicators than hexagonal feeder. Negative impact of mixing was more pronounced in hexagonal fed bucks than linear ones.

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REFERENCES

Andersen I.L., Roussel S., Ropstad E., Braastad B.O., Steinheim G., Janczak A.M., Jørgensen G.M. and Bøe K.E. (2008). Social instability increases aggression in groups of dairy goats, but with minor consequences for the goats' growth, kid production and development. *Appl. Anim. Behav. Sci.* **114,** 132-148.

Ángel-García O., Meza-Herrera C.A., Guillen-Muñoz J.M., Carrillo-Castellanos E., Luna-Orozco J.R., Mellado M. and Véliz-Deras F.G. (2015). Seminal characteristics, libido and serum testosterone concentrations in mixed-breed goat bucks receiving testosterone during the non-breeding period. *J. Appl. Anim. Res.* **43,** 457-461.

ARC. (1980). The Nutrient Requirements of Ruminant Livestock. Agricultural Research Council, Commonwealth Agricultural Bureax, Slough, United Kingdom.

Aschwanden J., Gygax L., Wechsler B. and Keil N.M. (2008). Social distances of goats at the feeding rack: Influence of the quality of social bonds, rank differences, grouping age and presence of horns. *Appl. Anim. Behav. Sci.* **114,** 116-131.

BAHFS. (2019). Basic Animal Husbandry and Fisheries Statistics. Ministry of Agriculture, Department of Animal Husbandry, Dairying and Fisheries, Krishi Bhawan, New Delhi, India.

Barnett J.L., Hemsworth P.H., Cronin G.M., Newman E.A., McCallum T.H. and Chilton D. (1992). Effects of pen size, partial stalls and method of feeding on welfare-related behavioural and physiological responses of group-housed pigs. *Appl. Anim. Behav. Sci.* **34,** 207-220.

Campbell J.R. and Marshall R.T. (2016). Dairy production and processing: The science of milk and milk products. Waveland Press, Hancock, USA.

Ďuračková Z. (2007). The Activity of Natural Compounds in Diseases Prevention and Therapy. SAP Slovakia Ltd., Slovakia.

Fritz W.F. (2017). Self-enurination in the domesticated male goat (*Capra hircus*). Ph D. Thesis. Rutgers Univ., New Brunswick, Canada.

Goetsch A.L. (2019). Recent research of feeding practices and the nutrition of lactating dairy goats. *J. Appl. Anim. Res.* **47,** 103-114.

Hasegawa N., Nisshiwaki A., Sugawara K. and Ito I. (1997). The effects of social exchange between two groups of lactating primiparous heifers on milk production, dominance order, behavior and adrenocortical response. *Appl. Anim. Behav. Sci.* **51,** 15-27.

Hyun Y., Ellis M., Riskowski G. and Johnson R.W. (1998). Growth performance of pigs subjected to multiple concurrent environmental stressors. *J. Anim. Sci.* **76,** 721-727.

Ison S.H., Donald R.D., Jarvis S., Robson S.K., Lawrence A.B. and Rutherford K.M.D. (2014). Behavioral and physiological responses of primiparous sows to mixing with older, unfamiliar sows. *J. Anim. Sci.* **92,** 1647-1655.

Katz L.S. (1987). Endocrine systems and behavior. The veterinary clinics of North America. *Food Anim. Pract.* **3,** 393-404.

Kaur G., Kaswan S., Singla M., Sharma A. and Lamba J.S. (2021). Behaviour of Beetal does and bucks at linear vs. hexagonal feeder with special reference to homologous regrouping. *Appl. Anim. Behav. Sci.* **234,** 1-11.

Keil N.M., Pommereau M., Patt A., Wechsler B. and Gygax L. (2017). Determining suitable dimensions for dairy goat feeding places by evaluating body posture and feeding reach. *J. Dairy Sci.* **100,** 1353-1362.

Kenney P.A. and Black J.L. (1984). Factors affecting diet selection by sheep. I. Potential intake rate and acceptability of feed. *Australian J. Agric. Res.* **35,** 551-563.

Kielland C., Boe K.E., Zanella A.J. and Osteras O. (2010). Risk factors for skin lesions on the necks of Norwegian dairy cows. *J. Dairy Sci.* **93,** 3979-3989.

Kumari A. and Patel B.H.M. (2015). Wastage of green fodder under different feeding systems in rohilkhandi kids. *Livest. Res. Int.* **3,** 74-76.

Li Y.Z., Wang L.H. and Johnston L.J. (2012). Sorting by parity to reduce aggression toward first-parity sows in group-gestation housing systems. *J. Anim. Sci.* **90,** 4514-4522.

Marrocco I., Altieri F. and Peluso I. (2017). Measurement and clinical significance of biomarkers of oxidative stress in humans. *Oxid. Med. Cell. Longev.* **2017,** 1-32.

Millman S.T. and Duncan I.J.H. (2001). Social cognition of farm animals. Pp. 35-72 in Social Behaviour in Farm Animals. L. Keeling and H. Gonyou, Eds., CABI Publishing, Wallingford, Oxon, United Kingdom.

Miranda-de La Lama G.C. and Mattiello S. (2010). The importance of social behaviour for goat welfare in livestock farming. *Small Rumin. Res.* **90,** 1-10.

Miranda-de la Lama G.C., Sepúlveda W.S., Montaldo H.H., María G.A. and Galindo F. (2011). Social strategies associated with identity profiles in dairy goats. *Appl. Anim. Behav. Sci.* **134,** 48-55.

Morgan K.N. and Tromborg C.T. (2007). Sources of stress in captivity. *Appl. Anim. Behav. Sci.* **102,** 262-302.

Neave H.W., von Keyserlingk M.A., Weary D.M. and Zobel G. (2018). Feed intake and behavior of dairy goats when offered an elevated feed bunk. *J. Dairy Sci.* **101,** 3303-3310.

Noack E. and Hauser R. (2004). Der ziegengerechte Fressplatz im Laufstall. FAT-Berichte Nr. 622/2004, Agroscope FAT Tänikon, Eidgenössische Forschungsanstalt für Agrar- und Landtechnik, CH-8356 Ettenhausen.

Nordmann E., Barth K., Futschik A., Palme R. and Waiblinger S. (2015). Head partitions at the feed barrier affect behaviour of goats. *Appl. Anim. Behav. Sci.* **167,** 9-19.

O'Connell N.E., Beattie V.E. and Moss B.W. (2003). Influence of social status on the welfare of sows in static and dynamic groups. *Anim. Welfare.* **12,** 239-249.

O'Driscoll K., Von Keyserlingk M.A.G. and Weary D.M. (2006). Effects of mixing on drinking and competitive behavior of dairy calves. *J. Dairy Sci.* **89,** 229-233.

Omokanye A.T., Balogun R.O., Onifade O.S., Afolayan R.A. and Olayemi M.E. (2001). Assessment of preference and intake of browse species by Yankasa sheep at Shika Niger. *Small Rumin. Res.* **42,** 201-208.

Pakhretia S. and Pirta R.S. (2010). A behavioural study of the sheep and goats of the transhumant gaddis. *J. Hum. Ecol.* **29,** 93-100.

Phillips C.J.C. and Rind M.I. (2001). The effects on production and behavior of mixing uniparous and multiparous cows. *J. Dairy Sci.* **84,** 2424-2429.

Rahal A., Kumar A., Singh V., Yadav B., Tiwari R., Chakraborty S. and Dhama K. (2014). Oxidative stress, prooxidants, and antioxidants: the interplay. *Biomed Res. Int.* **2014,** 1-19.

Sharma A., Kaswan S., Kumar S.S. and Lamba J.S. (2018). Feeding dynamics and performance of Beetal does in relation to body condition score at the time of mating. *Turkish J. Vet. Anim. Sci.* **42,** 649-657.

Silva N.C.D., Puchala R., Gipson T.A., Sahlu T. and Goetsch A.L.

(2018). Effects of restricted periods of feed access on feed intake, digestion, behavior, heat energy, and performance of Alpine goats. *J. Appl. Anim. Res.* **46,** 994-1003.

Slavnitsch K. (2008). Einflusseiner umgruppierung auf das sozialverhalten von milchziegen. MS Thesis. University of Veterinary Medicine, Vienna, Austria.

Soede N.M., Van Sleuwen M.J.W., Molenaar R., Rietveld F.W., Schouten W.P.G., Hazeleger W. and Kemp B. (2006). Influence of repeated regrouping on reproduction in gilts. *Anim. Reprod. Sci.* **96,** 133-145.

Szabo S. (2011). Social stress in large groups of dairy goats-Influence of presence of horns and introduction management of young goats. Ph D. Thesis. University of Veterinary Medicine, Vienna, Austria.

Szabò S., Barth K., Graml C., Futschik A., Palme R. and Waiblinger S. (2013). Introducing young dairy goats into the adult herd after parturition reduces social stress. *J. Dairy Sci.* **96,** 5644-5655.

Tanaka M., Kamiya Y., Suzuki T., Kamiya M. and Nakai Y. (2008). Relationship between milk production and plasma concentrations of oxidative stress markers during hot season in primiparous cows. *Anim. Sci. J.* **79,** 481-486.

Tuncer S.S., Şireli H.D. and Tatar A.M. (2016). Behavioral patterns of goats. Pp. 2369-2374 in Proc. 7 *VII* Int. Sci. Agric. Symp., Jahorina, Sarajevo, Bosnia and Herzegovina.

Upreti C.R., Kuwar B.S. and Panday S.B. (2005). Development and evaluation of improved feeders for goats suitable to stall-fed management system. *Nepal Agric. Res. J.* **6,** 78-83.

Von Keyserlingk M.A.G., Olenick D. and Weary D.M. (2008). Acute behavioral effects of regrouping dairy cows. *J. Dairy Sci.* **91,** 1011-1016.

Waiblinger S., Schmied-Wagner C., Nordmann E., Mersmann D., Szabo S., Graml C., Von Hof J., Maschat K., Grubmuller T. and Winckler C. (2010). Haltung von behornten und unbehornten Milchziegen in Großgruppen. Endberichtzum Forschungsprojekt 10019, Eigenverlag, Vienna, Austria.