



Performance and welfare status of stable and regrouped beetal does fed at hexagonal vs linear feeder

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ABSTRACT

Performance and welfare status of stable and regrouped Beetal does (N=28) was assessed at hexagonal and linear feeder (n=14 does per group, 7 lactating and 7 non-lactating). Stable groups were compared at hexagonal (D_H) and linear (D_L) feeders for a period of four weeks. Thereafter, does were regrouped (7 does interchanged, i.e. 4 lactating and 3 non-lactating) at hexagonal (D_{HM}) and linear (D_{LM}) feeder and compared as following four subgroups, i.e. hexagonal retained (D_{HR}), linear-to-hexagonal (D_{LH}), hexagonal-to-linear (D_{HL}) and linear retained (D_{LR}) does (n=7 each). Body weight, milk yield, feed intake, wastage, injuries and blood biochemical parameters were recorded. Blood samples were collected at weekly interval before regrouping and on day 1, 3, 7 and 14 after regrouping. Most of the parameters did not differ between feeder groups before as well as after regrouping. One doe received horn injury after regrouping at hexagonal feeder. Does retained at respective feeder (D_{HR} and D_{LR}) showed increase in plasma cortisol level after regrouping indicative of rise in stress to defend their stable position at feeder or space inside the pen. Results showed that two types of feeder had little influence on performance and welfare of stable does with marginal advantages at linear feeder in regrouped does.

Keywords: Beetal, Feeder, Mixing, Wastage, Welfare

Small ruminants are one of the key sources of rural livelihood security under different rearing systems irrespective of region, breed and type of available resources. In densely populated countries, intensive system is more economically viable option for goat production. Contrarily, goat being active and inquisitive animal faces several stressors in intensive production system hence various strategies are being explored to maximize performance of goats through coping up with these stressors. However, several stressors are unavoidable in modern production systems (Miranda-de La Lama and Mattiello 2010) like interventions such as regrouping, segregations, early weaning etc. Does are regrouped to make homogenous groups based on status of pregnancy, lactation, body condition etc for efficient management. Mixing of non-familiar goats in a group leads to decrease in feeding (Szabo 2011, Anonymous 2018) due to adverse effect on their psychological health as a result of separation from the companions and entry of new members leading to change in frequency of social interactions. The animal responds to stress swiftly while continuous social stress may even change the immune responses of the animals and, thus, make them prone to diseases (Pakhretia and Pirt 2010).

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Feeding management in confinement needs increased attention (Keil *et al.* 2017, Silva *et al.* 2018, Neave *et al.* 2018, Goetsch 2019, Kaur *et al.* 2021) as it can help in reducing conflicts and preventing injuries (Tuncer *et al.* 2016). Design of the feeder has direct implications on performance of any farm in terms of injuries (Kielland *et al.* 2010), feed intake and wastage, etc. Different types of goat feeders are used in different parts of the globe depending upon availability of local materials, feed type, rearing practices etc. Hexagonal feeder is conventionally being used for feeding of goats in many organized goat farms in India while linear feeder is in use at some of the goat farms as also reported in many other countries. Hence, this study was conducted to evaluate the effect of feeder type (hexagonal vs. linear) on performance of stable and regrouped Beetal does.

MATERIALS AND METHODS

The experiment was carried out at Goat Research Farm, Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana, Punjab (India). This investigation included 28 Beetal does which were divided into two treatment groups, i.e. hexagonal (D_H) and linear (D_L) feeder groups with mean body weight, age, parity and milk yield as: 33.47±2.23 vs. 34.44±2.41 kg; 888.29± 182.98 vs. 878.64±144.41 days; 2.14±0.63 vs. 2.00±0.38; 915.86±

103.63 vs. 940.93±119.35 g respectively. In the present study, group size was 14, i.e. closer to most stable group size (12–13) of does suggested by some researchers (Stanley and Dunbar 2013, Zobel *et al.* 2019). Both the groups included seven lactating (4th month of lactation) and non-lactating adult does each with three horned and eleven hornless (disbudded at early age) condition having similar access to covered (1.5 m²/doe) and open area (3 m²/doe). Animals were fed concentrate feed and unchaffed green fodder (berseem and oats) as per recommendations of the Goat Research Farm of the institute.

Two weeks before the start of trial, does were grouped as per experimental design and fed at neutral (large metallic tubs) type of feeders to have stability. Does at hexagonal (D_H) and linear (D_L) feeder were reared in two separate pens with almost similar dimensions of feeders, i.e. linear feeder (height: 53 cm, width: 45 cm and depth: 10 cm) and hexagonal feeder (height: 55 cm, radius: 44 cm and depth: 11 cm) and rest of the conditions were kept uniform. Feeder space per doe (≈ 40 cm/doe) was similar in both the groups. Does were monitored at these two type of feeders for a period of 4 weeks followed by mixing or regrouping. Seven does (2 high, 3 intermediate and 2 low ranked does in social hierarchy) based on index of success (Miranda-de la Lama *et al.* 2011) from each group or pen were interchanged. Mixed does at hexagonal (D_{HM}) and linear (D_{LM}) feeder were compared as following four subgroups, i.e. hexagonal retained (D_{HR}), linear-to-hexagonal (D_{LH}), hexagonal-to-linear (D_{HL}) and linear retained (D_{LR}) does (n=7 each). Relative performance of these mixed does was studied for a period of 2 weeks.

Body weight (weekly), milk yield (daily in twice frequency), feed intake and wastage (daily) were recorded following standard practices. Does were daily observed for their health status and injuries, if any. Blood samples were collected on 1st, 14th and 28th day before regrouping and on 1st, 3rd, 7th and 14th day after regrouping from the jugular vein (n=7 from each group) for separation of plasma and hemolysate (Andersen *et al.* 2008). Blood biochemical tests were performed for estimation of plasma cortisol, total

protein, albumin, globulin, lipid peroxidase, superoxide dismutase (SOD), catalase (CAT), glutathione reductase and total immunoglobulin as per standard techniques. All the recorded observations were arranged and analyzed using standard statistical methods with SPSS 20.0 software. One way and two-way analysis of variance (ANOVA) technique were used following Tukey's test for comparisons between and within feeder based groups.

RESULTS AND DISCUSSION

Body weight (BW) of the does fed at two different feeders did not differ during successive weeks (Table 1) and it slightly increased during pre-mixing period. Beetal breed is classified as medium to large sized breed and large sized goat breeds attain mature BW at later age (30–42 months vs. 18–24 months) than small sized breeds (Campbell and Marshall 2016). As experimental Beetal does had average age of 28–29 months (closer to mature BW), therefore, larger variations in BW due to feeder type were not hypothesized. Accordingly, influence of feeder type was not great enough to affect the BW in adult does. However, BW decreased non-significantly after regrouping in all the groups which is in consonance with earlier studies on mixing of goats (Andersen *et al.* 2008). Whereas, in unstable groups of pregnant goats (regrouped at weekly interval between four groups for 7 weeks period) mixing led to social instability but had no significant effects on growth (Andersen *et al.* 2008). BW marginally increased in interchanged does (D_{HL} and D_{LH}) during first week after regrouping probably due to overcoming the influence of negative interactions after regrouping through satisfaction of inquisitive tendency in the new pens, i.e. exploratory engagements as goats are more exploratory in nature (Houpt 2005) and responds to visual challenges through continuous learning responses (Oesterwind *et al.* 2016) and even seek challenging tasks that induces positive stress (Nawroth *et al.* 2019). Does fed on linear feeder had numerically higher ADG value (101.53±12.28 g/d) than hexagonal feeder (95.92±13.96 g/d).

The average daily milk yield (MY) of lactating does in

Table 1. Body weight (kg) of stable and regrouped does at hexagonal vs linear feeder

Period	D _H (n=14)	D _L (n=14)	P value		
Initial	32.27±2.18	32.71±1.94	0.88		
7 th day	33.50±2.29	34.02±1.90	0.86		
14 th day	33.46±2.32	33.94±1.90	0.87		
21 st day	34.10±2.32	34.68±1.94	0.85		
28 th day	34.96±2.25	35.56±2.02	0.84		
<i>Regrouped does</i>					
Period	D _{HR} (n=7)	D _{HL} (n=7)	D _{LH} (n=7)	D _{LR} (n=7)	P value
Initial*	32.94±2.46	36.97±3.80	37.06±3.40	34.06±2.30	0.80
7 th day	32.26±2.39	37.20±4.11	37.37±3.34	33.94±2.08	0.68
14 th day	31.56±2.39	36.00±3.65	36.20±3.42	33.46±2.01	0.71

Values have been presented as mean±standard error; D_H, does at hexagonal feeder; D_L, does at linear feeder; D_{HR}, hexagonal retained; D_{HL}, hexagonal to linear; D_{LH}, linear to hexagonal; D_{LR}, linear retained does; *just before regrouping.

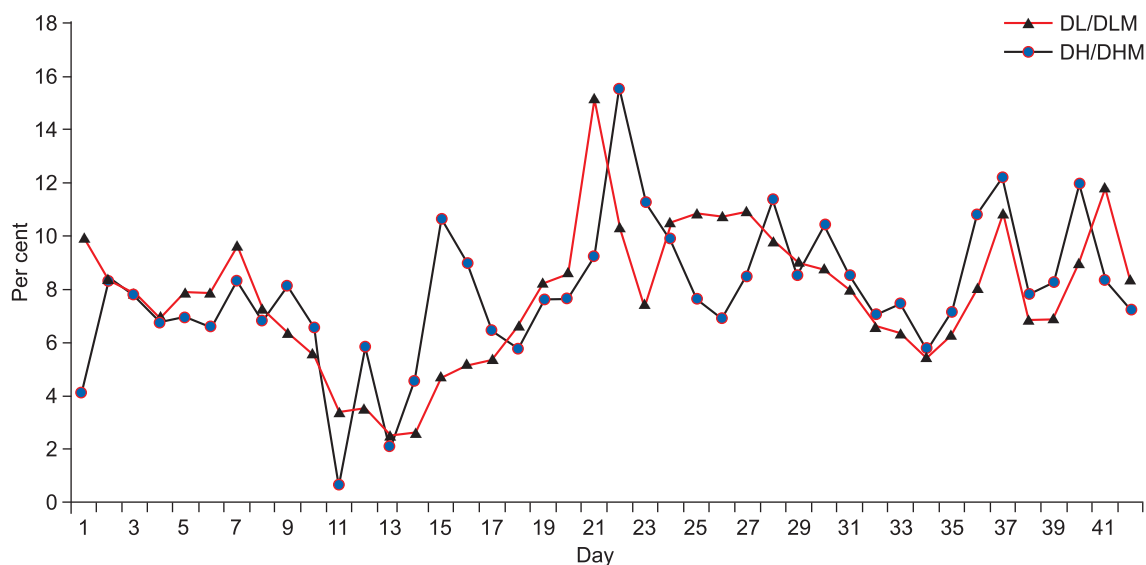


Fig.1. Daily green fodder wastage (%) at hexagonal vs. linear feeder in stable (1–28 days) and regrouped (29–42 days) does.

late lactation stage (4th month) fed at hexagonal and linear feeder did not differ statistically before as well as after mixing (Table 2). The decline in MY due to physiological status (4th month of lactation) was evident, however, overall decline in MY during four weeks period (pre mixing) was higher in D_H does (15.97%) with rate of decline 0.57% per day than D_L does (11.09%) with rate of decline 0.4% per day. After regrouping, decline rate increased in all the four subgroups (D_{HR}, D_{HL}, D_{LH} and D_{LR}). The overall decline in MY of does after regrouping (two weeks period) was 17.59%, 20.67%, 13.47% and 16.64% with rate of decline as 1.26%, 1.48%, 0.96% and 1.19% per day in D_{HR}, D_{HL}, D_{LH} and D_{LR} group respectively. The influence of feeder type was not sufficient to alter the MY statistically between different treatments. As lactating does in present study were in late lactation, they had natural declining trend of MY, however, feeder type had no influence on MY of does. Hasegawa *et al.* (1997) reported slight reduction in MY immediately after mixing. In this study, the rate of decline of daily MY of does after regrouping was more (nearly doubled) which is in consonance with the findings of Phillips and Rind (2001) in cows and Fernandez *et al.* (2007) in goats. Phillips and Rind

(2001) confirmed that mixing uniparous and multiparous cows at pasture results in a reduction in MY, which persists for several weeks, despite the higher space availability compared with housed cows. Keyserling *et al.* (2008) in a study on regrouping in dairy cows observed a decline in MY from 43.4±1.5 kg/d to 39.7±1.5 kg/d on the day of regrouping, but did not differ from premixing levels on subsequent days. Fernandez *et al.* (2007) observed in French Alpine breed, an increase in aggressive behaviour whenever goats were regrouped, but milk production decreased after the first regrouping only, which suggests that goats have a remarkable capacity to adapt to novelty and management practices that are stressful to them.

Concentrate feed was consumed completely on regular basis and wastage was negligible to be measured at both types of feeders. The average daily feed intake, total dry matter intake and wastage of green fodder at hexagonal vs. linear feeder before (four week period) and after (two week period) regrouping did not differ (Table 3). Pattern of daily green fodder wastage (%) at hexagonal and linear feeder has been shown in Fig. 1 which indicates that wastage of green fodder had almost similar pattern at both types of

Table 2. Average daily milk yield (g/d) of stable and regrouped does at hexagonal vs linear feeder

Period	D _H (n=7)	D _L (n=7)	P value		
Week 1	844.57±71.22	913.20±66.08	0.50		
Week 2	813.43±77.74	906.71±66.38	0.38		
Week 3	614.84±66.74	677.61±78.60	0.55		
Week 4	709.65±59.36	811.96±183.06	0.28		
<i>Regrouped does</i>					
Period	D _{HR} (n=3)	D _{HL} (n=4)	D _{LH} (n=4)	D _{LR} (n=3)	P value
Initial*	769.14±85.99	665.04±84.20	811.36±58.19	812.76±163.51	0.66
Week 1	714.81±71.61	610.71±88.65	791.57±74.98	805.91±135.87	0.44
Week 2	633.81±68.54	527.57±66.84	702.04±71.44	677.52±67.85	0.31

Table 3. Feed intake and wastage at hexagonal vs. linear feeder for stable and regrouped Beetal does

Feeding parameter	Stable does			
	Period	D _H	D _L	P value
Daily green fodder intake (on fresh basis in kg)	Week 1	46.51±0.28	45.81±0.21	0.07
	Week 2	47.50±0.51	47.76±0.37	0.69
	Week 3	48.37±1.15	48.07±0.61	0.82
	Week 4	51.95±1.11	51.36±0.86	0.68
Daily dry matter intake (kg)	Week 1	13.54±0.05	13.42±0.04	0.07
	Week 2	13.72±0.09	13.76±0.07	0.69
	Week 3	13.88±0.21	13.82±0.11	0.82
	Week 4	14.52±0.20	14.42±0.16	0.68
Daily green fodder wastage [kg (%)]	Week 1	3.48±0.28 (6.97±0.55)	4.19±0.21 (8.37±0.41)	0.06
	Week 2	2.49±0.51 (4.99±1.01)	2.24±0.36 (4.48±0.73)	0.69
	Week 3	4.20±0.34 (8.06±1.64)	4.06±0.80 (7.69±1.38)	0.89
	Week 4	5.76±0.58 (10.13±1.10)	5.78±0.31 (10.10±0.46)	0.98
Total green fodder wastage (on fresh basis in kg)	In 4 weeks	111.66	113.98	–

Feeding parameter	Regrouped does			
	Period	D _{HM}	D _{LM}	P value
Daily total green fodder intake (on fresh basis in kg)	Week 1	55.29±0.34	55.67±0.31	0.43
	Week 2	54.28±0.47	54.68±0.43	0.55
Daily total dry matter intake (kg)	Week 1	15.12±0.06	15.19±0.05	0.43
	Week 2	14.94±0.08	15.01±0.08	0.55
Green fodder wastage kg (%)	Week 1	4.71±0.34 (7.85±0.57)	4.33±0.31 (7.22±0.52)	0.43
	Week 2	5.72±0.47 (9.53±0.78)	5.32±0.44 (8.87±0.73)	0.55
Total green fodder wastage [on fresh basis in kg]	In 2 weeks	72.99	67.55	–
Overall green fodder wastage (on fresh basis in kg)	In 6 weeks	184.65	181.53	–

Values have been presented as mean±standard error (except absolute totals); values in parenthesis indicate percentage.

feeder during successive days of pre-mixing (i.e. in stable does). However, wastage at hexagonal feeder was higher for relatively more number of days than linear feeder after uniform regrouping of does leading to overall more green fodder wastage at hexagonal feeder (184.65 kg) compared to the linear feeder (181.53 kg) for feeding of 14 does during 6 weeks period. Summary of feeding of Beetal does at hexagonal vs. linear feeder (Table 4) indicated that dry matter requirement (g/kg BW) increased after regrouping in both the feeder type groups. Average required dry matter (g/kg BW) was numerically more in the hexagonal fed does

than linear fed does during all the weeks (before as well as after regrouping). Feed intake is one of the most important factors for the productivity of small ruminants and is generally considered to increase when there is competition among animals. Zemmeling and Manneetje (2002) concluded that dietary intake of goats in stall-fed is generally lower because they have more selective feeding behavior and selectivity takes place at maximum level when grass/fodder is abundant with wide variety and decrease if fodder is limited. However, in present investigation, both the groups were offered similar quantity of feed with uniform feeder

Table 4. Feed utilization in Beetal does on hexagonal vs. linear feeder

Week	Total DMI (D _H) (kg/week/pen)	Total DMI (D _L) (kg/week/pen)	Total body weight (D _H) (kg/pen)	Total body weight (D _L) (kg/pen)	DM required (D _H) (g/kg BW basis)	DM required (D _L) (g/kg BW basis)
Week 1	94.80	93.91	469.00	476.40	28.88	28.16
Week 2	96.04	96.37	468.40	475.20	29.29	28.97
Week 3	97.13	96.75	477.40	485.45	29.07	28.47
Week 4	101.65	100.91	489.40	497.80	29.67	28.96

Regrouped does						
	D _{HM}	D _{LM}	D _{HM}	D _{LM}	D _{HM}	D _{LM}
Week 1	105.86	106.34	485.40	498.00	31.15	30.50
Week 2	104.58	105.09	474.30	486.20	31.50	30.88

DMI, Dry matter intake.

space at two different feeder types. Feeder type did not influence feed intake in present study. After regrouping, a comparative increase in feed intake in does was noticed in both types of feeder which might be due to more competitiveness among new group mates, contrarily overall feeding activities (positive as well as negative) were decreased at both type of feeders (Kaur 2019). Upreti *et al.* (2005) noted that 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%) and hay rack (29.61, 16.66%). Wastage of straw (black bean) and fodder twigs (tanki) too had similar trend. Findings of Upreti *et al.* (2005) clearly indicates that wastage at rectangular and chain barrel feeders (both had linear dimensions) were lesser than hexagonal and circular feeders (round dimensions). Kumari and Patel (2015) concluded that linear feeding trough helped in saving the green fodder (wastage) in comparison to circular (hexagonal) feeder and provision of unchopped fodder in circular feeder did not give any advantage over linear feeding trough. In line with above findings, overall wastage (42 days) was lower at linear feeder than hexagonal feeder but difference was smaller in this study. The reason for comparatively higher feed losses at hexagonal/circular feeder could be due to relatively more instability while feeding due to ability of neighbouring goats to approach/attack from wider angles while exhibiting competitive feeding interactions (Kaur *et al.* 2021). The depth of both the feeders were nearly similar (10 vs. 11 cm in linear vs. hexagonal feeder), however, the edges of linear feeder were more round and broader, making the feeder surface shallower than hexagonal feeder which had relatively acute edges and it was very likely that wastage would have been

much lower at linear feeder with similar type of edges. Differences in amount of feed wastage (%) in various studies could be due to variations in feeder type, feeder space per animal, feeder depth, type of feed and type of animals. Variations in eating activities observed in goat breeds may result from differences in body size and oral morphology (Provenza *et al.* 2003).

Goats had no injury and ailment at two different feeders during pre-mixing period of 4 weeks while one case of horn injury was noted a day after regrouping in doe shifted to hexagonal feeder (D_{LH}). Increases in injuries after regrouping in group housed pigs have been noted in some studies (Soede *et al.* 2006, Li *et al.* 2012). 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, Szabo *et al.* 2013). However, in present investigation only one injury noted in doe shifted to hexagonal feeder a day after regrouping. One of the most likely causes for relatively more harmful encounters at hexagonal feeder could be easy access to neighbouring doe'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. It is indicative that regrouping is less harmful at linear feeder than hexagonal feeder.

Blood parameters of stable Beetal does fed at hexagonal vs. linear feeder showed that most of the parameters did not differ except SOD (1st day) and total immunoglobulin (28th day) (Table 5). There is very little information about the oxidative stress parameters (SOD: Superoxide dismutase, Glutathione reductase, CAT: Catalase and MDA:

Table 5. Blood parameters of stable and regrouped Beetal does fed at hexagonal vs. linear feeder

Parameter	Stage	D_H (n=7)	D_L (n=7)	P value
Protein (g/dl)	1 st day	6.54±0.15	6.58±0.21	0.88
	14 th day	6.77±0.31	6.04±0.15	0.06
	28 th day	6.28±0.24	6.22±0.07	0.81
Albumin (g/dl)	1 st day	3.32±0.03	3.32±0.13	0.97
	14 th day	3.15±0.11	2.99±0.11	0.32
	28 th day	2.95±0.06	3.07±0.09	0.31
Globulin (g/dl)	1 st day	3.23±0.19	2.90±0.21	0.26
	14 th day	3.62±0.23	3.05±0.16	0.06
	28 th day	3.33±0.20	3.15±0.07	0.41
Cortisol (ng/ml)	1 st day	39.19±8.66	25.68±2.50	0.16
	14 th day	18.74±5.22	17.86±2.87	0.89
	28 th day	26.79±3.13	24.53±4.05	0.67
Lipid peroxidise (nmol	1 st day	503.14±39.14	584.86±10.14	0.07
MDA produced/g Hb)	28 th day	400.15±62.36	351.73±25.54	0.49
SOD (units/mg Hb)	1 st day	29.00±1.45 ^B	36.14±1.55 ^A	0.01
	28 th day	38.37±5.10	34.65±3.26	0.55
Glutathione reductase (units/ml)	1 st day	0.16±0.06	0.22±0.08	0.59
	28 th day	0.89±0.42	0.58±0.36	0.59
Catalase (U/g Hb)	1 st day	0.163±0.12	0.26±0.08	0.51
	28 th day	0.21±0.13	0.05±0.02	0.25
Immunoglobulin (mg/ml)	1 st day	4.06±1.14	2.52±1.06	0.34
	28 th day	3.88±1.02 ^A	1.40±0.35 ^B	0.04

(Table 5. ... Contd.)

Parameter	Regrouped does					P-value
	Stage	D _{HR} (n=4)	D _{HL} (n=3)	D _{LH} (n=3)	D _{LR} (n=4)	
Protein (g/dl)*	Initial [#]	6.62±0.18 ^c	5.83±0.39	6.09±0.04 ^b	6.32±0.09 ^b	0.11
	Day 1	6.73±0.14 ^c	6.28±0.57	6.58±0.38 ^{ab}	6.31±0.12 ^b	0.68
	Day 3	7.06±0.48 ^{bc}	6.93±1.24	7.25±0.30 ^{ab}	6.61±0.09 ^{ab}	0.51
	Day 7	8.13±0.09 ^a	7.30±0.58	7.49±0.36 ^a	7.00±0.11 ^a	0.07
	Day 14	7.72±0.21 ^{ab}	7.30±0.40	7.24±0.08 ^{ab}	6.95±0.13 ^a	0.14
Albumin (g/dl)*	Initial	3.05±0.06 ^{bAB}	2.82±0.06 ^{bB}	2.87±0.13 ^{bAB}	3.23±0.08 ^A	0.03
	Day 1	3.13±0.11 ^b	3.03±0.09 ^b	3.17±0.32 ^{ab}	3.20±0.12	0.89
	Day 3	3.28±0.06 ^b	3.37±0.22 ^{ab}	3.37±0.09 ^{ab}	3.03±0.28	0.56
	Day 7	4.03±0.15 ^a	3.87±0.22 ^a	3.93±0.27 ^a	3.75±0.17	0.76
	Day 14	3.95±0.09 ^a	3.50±0.15 ^{ab}	3.43±0.23 ^{ab}	3.58±0.12	0.10
Globulin (g/dl)	Initial	3.57±0.19	3.01±0.36	3.23±0.14	3.08±0.05	0.22
	Day 1	3.59±0.09	3.26±0.49	3.41±0.17	3.12±0.23	0.57
	Day 3	3.98±0.22	3.58±0.51	3.86±0.28	3.58±0.27	0.74
	Day 7	4.13±0.17	3.43±0.37	3.56±0.38	3.25±0.09	0.11
	Day 14	3.77±0.17	3.83±0.35	3.82±0.24	3.40±0.09	0.43
Immunoglobulin (mg/ml)	Initial	2.27±0.32 ^B	6.02±1.73 ^A	1.25±0.62 ^B	1.51±0.47 ^B	0.01
	Day 1	3.21±0.46 ^B	6.92±1.36 ^A	1.19±0.76 ^B	2.16±0.56 ^B	0.01
	Day 3	3.17±0.31 ^{AB}	6.66±1.63 ^A	1.49±0.66 ^B	2.24±0.49 ^B	0.01
	Day 7	3.24±0.35	5.67±2.37	1.90±0.81	2.08±0.44	0.14
	Day 14	2.95±0.40	5.32±0.34	1.64±0.72	2.00±0.36	0.15
Cortisol* (ng/ml)	Initial	24.63±1.83 ^b	29.66±7.39	29.31±8.12	20.95±3.81 ^{ab}	0.60
	Day 1	75.03±5.98 ^a	40.42±5.47	64.28±31.69	49.11±12.38 ^a	0.44
	Day 3	25.11±9.80 ^b	14.87±6.82	91.88±47.26	16.56±5.77 ^b	0.10
	Day 7	18.09±6.10 ^b	23.64±4.50	27.03±11.46	16.17±4.54 ^b	0.67
	Day 14	16.38±3.65 ^b	18.84±5.04	24.26±11.28	16.29±4.57 ^b	0.60
Lipid peroxidise (nmol MDA produced/g Hb)*	Initial	354.01±37.95	461.66±145.12	391.26±31.76	322.09±33.12 ^b	0.55
	Day 1	425.40±16.91	407.99±13.73	446.97±37.27	455.30±43.97 ^a	0.74
	Day 3	406.83±14.37	413.63±26.63	432.30±50.1	394.35±12.02 ^{ab}	0.78
	Day 7	384.23±9.57	443.13±46.01	508.70±73.89	407.75±15.14 ^{ab}	0.18
SOD (units/mg Hb)*	Initial	43.63±7.94 ^a	31.36±3.60 ^{ab}	37.38±5.45	32.30±4.25 ^{ab}	0.44
	Day 1	39.75±3.06 ^{ab}	39.67±3.84 ^a	36.33±6.76	38.75±1.55 ^a	0.92
	Day 3	22.95±2.20 ^b	25.33±3.09 ^{ab}	19.23±1.13	21.28±0.85 ^c	0.26
	Day 7	24.65±3.87 ^{ab}	21.93±1.35 ^b	20.77±3.23	26.05±1.90 ^{bc}	0.58
Glutathione reductase (units/ml)	Initial	1.42±0.64	0.19±0.05	0.21±0.09	0.86±0.63	0.34
	Day 1	0.22±0.07	0.26±0.04	0.13±0.05	0.18±0.08	0.63
	Day 3	0.26±0.08	0.49±0.03	0.41±0.20	0.26±0.02	0.32
	Day 7	1.67±0.68	0.53±0.21	1.59±0.67	0.55±0.09	0.24
Catalase (units/g Hb)	Initial	0.12±0.04	0.33±0.31	0.08±0.03	0.04±0.01	0.48
	Day 1	0.11±0.03	0.10±0.03	0.19±0.04	0.07±0.02	0.12
	Day 3	0.20±0.08	0.09±0.02	0.16±0.05	0.06±0.02	0.21
	Day 7	0.11±0.02 ^A	0.05±0.00 ^{AB}	0.08±0.03 ^{AB}	0.03±0.00 ^B	0.02

Values bearing different capital letter as superscript within a row indicates significant difference at given P value while values with different small letter as superscript column-wise indicates significant difference at *(P<0.05); #, initial means day before mixing/regrouping.

Malonylaldehyde) in goats. 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 (Durackova 2007) of the imbalance between oxidants and antioxidants in favour 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). Plasma SOD activity of does on 1st day at linear feeder was significantly (P<0.01) higher but had no difference at the end (28th day) (before regrouping). However, total immunoglobulin level

was significantly (P < 0.05) higher in hexagonal fed does on 28th day. After regrouping, blood parameters had no significant difference except total immunoglobulin (1st and 3rd day) and catalase activity (7th day) between the four groups (D_{HR}, D_{HL}, D_{LH} and D_{LR}). Albumin concentration was significantly (P<0.05) higher in D_{LR} than D_{HL} does on the (initial day) before mixing. Total immunoglobulin level remained significantly (P<0.01) higher in D_{HL} group than other groups till day 3rd after regrouping. Whereas, activity of catalase enzyme was higher (P<0.05) in D_{HR} group on 7th day post-mixing than other groups. After regrouping,

many biochemical differences (protein, albumin, lipid peroxidase, SOD and cortisol) were seen within groups indicating disturbance in physiological status of the does. The concept of stress is often expressed based on the physiological parameters such as elevated stress hormone (cortisol) secretion (Fazio *et al.* 2008). An increase in cortisol with social mixing has been demonstrated previously when mixing pregnant gilts with unfamiliar multiparous sows (Rutherford *et al.* 2009) and unfamiliar gilts (Couret *et al.* 2009). However, in the present study, plasma cortisol values did not differ significantly among feeder type groups before mixing but cortisol level increased ($P < 0.05$) one day after regrouping in does retained at respective feeders (D_{HR} and D_{LR}) and then declined. This can be probably due to increased tendency of retained does to defend their position or space at feeder or in the pen than shifted does. These findings can be collaborated with numerical decline in body weight of does retained at respective feeder at first week after regrouping. Contrarily, body weight marginally increased in interchanged does (D_{HL} and D_{LH}) during first week after regrouping probably due to overcoming the influence of negative social interactions after regrouping through satisfaction of inquisitive tendency in the new pens, i.e. exploratory engagements (eustress). It indicates lesser influence of feeder type than regrouping on Beetal does.

Overall the results indicate that feeder type (hexagonal vs. linear) had lesser influence on the performance of stable group of Beetal does. Regrouped does had marginal advantage at linear feeder over hexagonal one in terms of injury and feed wastage. Regrouping led to marginal negative influence on body weight and milk yield of does. Does retained at respective feeder type had elevated stress level probably to defend their position or space at the feeder or inside the pen.

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