Effect of quantitative feed restriction and realimentation on growth, carcass traits and economics in stallfed Barbari kids

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Received: 23 August 2018; Accepted: 11 September 2018

ABSTRACT

Four months old 24 Barbari kids were allotted randomly to ad lib. feeding up to 12 months age, 20% (mild) and 40% (moderate) feed restriction at 5th and 6th months (MMFR) and 20, 40, 60% (severe) feed restriction (MMSFR) each of 20 days duration during 5th and 6th months followed by realimentation up to 12 months age. At the end of realimentation, 4 kids from three groups were slaughtered and carcass traits evaluated along with its economics. The kids did not differ significantly in growth and carcass traits. Body weight change indicated that the occurrence of compensatory growth in feed restricted kids proportional to body weight loss occurred during restriction. The feed cost/kg gain was lowest in MMSFR kids followed by ad lib. fed and MMFR kids. Therefore, stallfed Barbari kids shall easily be maintained up to 60% lower feed for 60 days thereby increasing the profit of stallfed kid rearing.

Key words: Barbari goat kids, Carcass traits, Feed restriction, Growth, Stall feeding

The goat production system is gradually shifting from less input extensive production for livelihood and nutritional security to medium and high input semi intensive and intensive production, respectively, for commercial large scale enterprise. Feeding alone accounts nearly about 65–75% of total variable cost of goat production under intensive stall feeding system. Any reduction in cost of feeding will make the goat enterprise more remunerative and thereby more attractive. Besides the use of cheap and non conventional feeding materials and nutritional manipulations, there is a need to manipulate management practices to improve feed conversion efficiency of animals especially stallfed goats raised under broiler kid production system to meet the ever increasing demand for goat meat.

Feed restriction occurs in livestock and poultry either naturally during drought, disasters or induced artificially as a management tool to reduce feed cost while maintaining productivity of meat animals by exploiting compensatory growth mechanism. Similarly, feed restriction can be either quantitative by reducing the amount of feed offered or qualitative by reducing the nutrient content in feed. The response in terms of compensatory growth after feed restriction and realimentation varies with species, breed, age, sex, physiological stage, rearing system, quantity and quality of feed, duration and severity of feed restriction. In monogastric animals, feed restriction methodologies have been standardized through many experiments and are in practice since decades for maximum production (Lee et al. 2002, Demir et al. 2004). Similarly, in ruminant animals like cattle and sheep, several studies reported the occurrence of nil, partial and complete compensatory growth after feed restriction (Thornton et al. 1979, Keogh et al. 2015, Babu et al. 2017, Ohja et al. 2018). Ryan et al. (1993) observed that complete compensation occurs in sheep but not in cattle during realimentation and the compensatory growth was mainly due to increased efficiency of restricted animals during first 12 weeks of realimentation and thereafter due to increased feed intake. Raju et al. (2015) reported that with 15% feed restriction with dietary protected lipid supplementation in Deccani lambs yielded higher ADG, feed efficiency and carcass traits than 30% restricted and adlib fed lambs. Similarly, Abouheif et al. (2015) suggested that the implementation of 10% feed restriction followed by two weeks of realimentation just before slaughtering would be appreciated by both consumer and sheep producer and can thus be adopted as a nutritional practice for finishing and fattening Najdi lambs. Even up to 30% feed restriction in 3 months old ram lambs revealed higher weight gain, FCE and carcass yield as compared to ad lib. fed lambs (Babu et al. 2017).

Compared to other livestock species and poultry, the studies of the effect of feed restriction on performance and economics in growing goat kids are lacking especially in Indian goat breeds and needs detailed experiments covering all the factors affecting the response of feed restriction on productivity and profitability of goat production so as to recommend the feed restriction as routine feeding
intervention under package of practices for commercial goat kid production. Salem et al. (1989) studied the effects of periodic feed restriction for 5, 10 and 15 days and realimentation for 10 days on body weight change, feed digestibility and nitrogen balance in mature Baladi bucks. Realimentation in 8 months old kids of Iran after 75 days of feed restriction was associated with a greater daily gain without any deleterious effect on carcass composition (Dashtizadeh et al. 2008). The feed restriction up to two months followed by six months realimentation period did not affect the carcass characteristics of the kids adversely in post weaned Sirohi kids (Sharma et al. 2009). In pre weaned Jamunapari kids, milk restriction with normal access to creep feeding encouraged solid feed consumption by goat kids with early adaptation for intake of solid foods leading to higher weight gain and average daily gain (Vyas et al. 2012). Kumar et al. (2017) reported that feed restriction considerably reduced methane emission and improved the energy utilization efficiency in one year old female goats.

Considering the paucity of information on effect of feed restriction on performance, carcass traits of growing post weaned stallfed goat kids, the present study was planned with the aim to assess the weight gain, feed intake, carcass traits and economics of different degrees of feed restriction followed by realimentation in stallfed Barbari kids, which is proved to be the best suited goat breed for intensive stall feeding conditions based on its small body size.

MATERIALS AND METHODS

Four months old 24 kids of Barbari breed (12 females and 12 males) were divided equally in to 3 groups based on their body weight, age, sex and type of birth and allotted randomly to Group-1: ad lib. feeding up to 12 months age; Group-2: Feeding @ 80% of ad lib. consumption (mild restriction) during 5th month and 60% (moderate restriction) during 6th month of age, i.e. mild and moderate feed restriction (MMFR) followed by realimentation up to one year of age; Group-3: Feeding @ 80, 60 and 40% (severe restriction) of ad lib. consumption each of 20 days duration during 5th and 6th month age, i.e. mild, moderate and severe feed restriction (MMSFR) followed by realimentation up to one year of age. The kids were maintained in individual kid pens with 1.2 m × 1.2 m cages under asbestos sheet roofed shed. They were taken out of cages for about two h during the morning. All management practices were uniformly followed throughout the trial period.

The kids were fed complete feed individually which consisted of 50% concentrate mixture (Maize 25%, Til cake 10%, wheat bran 17%, mineral mixture 2%, common salt 1%) and 50% dry fodder of arhar (Cajanus cajan)/gram (Cicer arietinum) crops. The weighed quantity of complete feed pellets were offered to kids daily at about 10.00 AM and the refusal, if any, was recorded at about 08.00 AM next day. The feed intake for individual kids was recorded at start and end of each feed restriction stages at 10 days interval and at monthly interval thereafter, i.e. during realimentation stage. The average feed intake (% of body weight) in group-1 at 10 days interval during dietary restriction and at 15 days during realimentation which served as the basis for calculating quantity of feed served during different stages of growth in group-2 and group-3. On similar intervals, body weight recording of individual kids was carried out. Each time, body weight was recorded for 3 consecutive days and average was considered. Fresh water was offered twice daily.

After six months of re-alimentation period, 4 male kids from each group were slaughtered, after 16–18 h fasting and free access to potable water. Bleeding, evisceration and dressing were done as per the standard commercial procedures. The carcass component as expressed in this study was hot carcass weight excluding any offal or fat. Empty live weight was calculated as the difference between slaughter weight and weight of digestive content. The dressing percentages on the basis of pre-slaughter weight (SW) as well as an empty live weight (ELW) were also recorded as per Agnihotri et al. (2006). The data were statistically analysed using mixed model least squares maximum likelihood programme PC-2 as per Harvey (1990).

RESULTS AND DISCUSSION

The body weight has been the only measuring criteria while deciding the price of the meat animals reared under different production systems. Research data reveals that the feed restriction technology could strategically be used as a management tool to reduce feed cost for growing animals.

Growth: The body weight of ad lib. and feed restricted kids during restriction and realimentation phases is given Table 1. It is evident from table that the body weight of feed restricted kids decreased marginally during restriction phase whereas reverse trend was true in ad lib. fed kids. During the initial 30 days of feed restriction (5th month age), the body weight increased by 10.16% in ad lib. fed kids and decreased by 3.52 and 8.44% in MMFR and MMSFR kids, respectively. However, the difference of body weight between ad lib. fed and feed restricted kids during first 30 days of feed restriction was statistically nonsignificant. Similarly, there was no difference between body weight of kids underwent two levels of restriction during this period which indicated that kids can be maintained easily with lower quantity of feed for shorter duration up to one month in situations like disaster, feed shortage and inclement weathers, and as a measure to save feed without compromising the growth of stall fed kids. However, the second month of feed restriction (6th month age) significantly (P<0.01) reduced body weight in feed restricted kids as compared to ad lib. fed kids, though the reduction among two restricted groups was statistically similar. The change in body weight during this period was ~6.96% in MMFR kids, ~10.01% in MMSFR kids and 3.39% in ad lib. fed kids. Salem et al. (1989) reported 8% body weight loss in 10% concentrate restriction followed by 10 days realimentation with repeated cycles till 105 days experimental period. Muna and Ammar (2001) observed
During realimentation phase, the body weight of feed restricted kids at both levels continued to be significantly lower than ad lib. fed kids even after 60 days of realimentation, though the body weights of kids between two levels of restriction after realimentation did not differ significantly which corroborates the findings of Dashtizadeh et al. (2010) in eight months old native goats of Iran. Thereafter, the body weights of kids of all three groups were statistically similar till the end of trial. The body weight change during first 15 days of realimentation phase in MMFR restricted kids were 14.88, 17.26, 12.58; 21.93, 17.1, 10.28; respectively. In contrary, Hooda and Upadyay (2014) reported that kids underwent 50% feed restriction followed by realimentation in eight months old crossbred male calves as compared to ad lib. fed calves.

On realimentation, the ADG of kids underwent restriction increased sharply vis-à-vis ad lib. fed kids. The ADG in MMSFR kids showed steady increase throughout the realimentation phase whereas, it did not show any specific trend in MMFR kids. The overall ADG during realimentation phase after feed restriction was significantly higher (80.3 g) in MMSFR kids followed by 62.6 g in MMFR kids and lowest (59.2 g) in ad lib. fed kids. The higher ADG in severely restricted kids could be due to the body weight loss during restriction phase. The mean ADG in MMSFR kids during 40–60 and 0–30 days of realimentation were −12.5 and −10 g as compared to 10.0 and 1.7 g in MMFR kids. Sahlu et al. (1999) observed body weight loss of 10 g/day only at severe feed restriction as compared to body weight gain of 5 g/day at moderate restriction and 24 g/day at low restriction and 13 g/day in ad lib. fed kids. On realimentation, the ADG in respective wethers were reported as 87, 31, 36 and 14 g/day. Abouheif et al. (2015) observed body weight loss (ADG) of 7.6 and 26.9% in 10 and 20% feed restriction during restriction phase that lead to 35 and 30.5% faster ADG than the control, respectively, during realimentation period in lambs. Suwignyo et al. (2017) recorded mean ADG in control, 30 days feed restriction with 60 days realimentation and 60 days feed restriction with 30 days realimentation in eight months old 60% feed restricted Kacang goat kids of Indonesia as 75.00, 65.49 and 15.58 g, respectively. In contrary, Hooda and Upaday (2014) reported that kids underwent 50% feed restriction followed by thermal stress could not compensate growth after removal of thermal stress and ad lib. feeding in four months old Alpine × Beetal crossbred kids.

Dry matter intake: Table 2 shows the DMI in Barbari kids during different stages of feeding. It is obvious from the data that DMI increased steadily in ad lib. fed kids with the increase in body weight over the period (Table 1). The quantity of DMI in feed restricted kids was calculated taking in to consideration of DMI in ad lib. fed kids as explained by previous researchers (Ryan et al. 1993, Kamalzadeh et al. 1998, Raju et al. 2015, Suwignyo et al. 2015, Babu et al. 2017). However, Suwignyo et al. (2017) reported that 60% feed restriction up to 30 days followed by 60 days realimentation in eight months old Kacang goat kids yielded significantly higher weight gain (7.39 kg) as compared to 60 days feed restriction with 30 days realimentation (2.21 kg) and control kids (5.90 kg).

The trend of average daily gain of kids during restriction and realimentation phase has been depicted in Fig. 1. The overall mean ADG of MMFR and MMSFR kids were 6.3 and −4.2 g, respectively as against 54.8 g in ad lib. fed kids during feed restriction of 60 days. This indicates that the stallfed Barbari kids shall be able to withstand feed restriction up to 40% without body weight loss and even up to 60% restriction for 20 days (MMSFR) with minimum weight loss. Ohja et al. (2018) also observed similar body weight gain and ADG in 15% feed restricted 3–4 months old crossbred male calves as compared to ad lib. fed calves.

Table 1. LSM±SE for live weight (kg) of Barbari kids during feed restriction and realimentation

| Period of weighing | ADLIB | MMFR | MMSFR | Significance |
|-------------------|-------|------|-------|--------------|
| **Dietary Restriction Phase** |
| 0th day | 8.08±0.39 | 8.08±0.39 | 8.08±0.09 | NS |
| 10th day | 8.48±0.41 | 7.86±0.41 | 8.04±0.41 | NS |
| 20th day | 9.21±0.41 | 8.04±0.41 | 8.11±0.41 | NS |
| 30th day | 9.48±0.46 | 8.41±0.46 | 8.13±0.46 | NS |
| 40th day | 9.98±0.45 | 8.26±0.45 | 8.17±0.45 | * |
| 50th day | 10.83±0.46 | 8.36±0.46 | 7.95±0.46 | ** |
| 60th day | 11.37±0.46 | 8.46±0.46 | 7.83±0.46 | ** |
| **Realimentation Phase** |
| 75th day | 12.44±0.51 | 9.23±0.51 | 8.47±0.51 | ** |
| 90th day | 12.99±0.56 | 9.95±0.56 | 9.23±0.59 | ** |
| 105th day | 13.54±0.57 | 10.49±0.61 | 10.28±0.61 | ** |
| 120th day | 14.55±0.63 | 11.63±0.75 | 11.55±0.66 | ** |
| 180th day | 17.72±0.96 | 15.57±0.89 | 16.49±0.83 | NS |
| 235th day | 21.73±0.99 | 19.42±0.99 | 21.88±1.08 | NS |

ADLIB- ad lib. fed group; MMFR, mild and moderate feed restricted group; MMSFR, Mild, moderate and severe feed restricted group; RES, Feed restriction; REA, Feed realimentation. * P<0.05, **P<0.01.

1.78% weight loss in 12–15 months aged male desert goats during one week feed restriction along with water restriction during summer season.

The mean ADG during realimentation phase whereas, it did not show any specific trend in MMFR kids. The overall ADG during realimentation phase after feed restriction was significantly higher (80.3 g) than MMFR kids followed by 62.6 g in MMSFR kids and lowest (59.2 g) in ad lib. fed kids. The higher ADG in severely restricted kids could be due to the body weight loss during restriction phase. The mean ADG in MMSFR kids during 40–60 and 0–30 days of realimentation were −12.5 and −10 g as compared to 10.0 and 1.7 g in MMFR kids. Sahlu et al. (1999) observed body weight loss of 10 g/day only at severe feed restriction as compared to body weight gain of 5 g/day at moderate restriction and 24 g/day at low restriction and 13 g/day in ad lib. fed kids. On realimentation, the ADG in respective wethers were reported as 87, 31, 36 and 14 g/day. Abouheif et al. (2015) observed body weight loss (ADG) of 7.6 and 26.9% in 10 and 20% feed restriction during restriction phase that lead to 35 and 30.5% faster ADG than the control, respectively, during realimentation period in lambs. Suwignyo et al. (2017) recorded mean ADG in control, 30 days feed restriction with 60 days realimentation and 60 days feed restriction with 30 days realimentation in eight months old 60% feed restricted Kacang goat kids of Indonesia as 75.00, 65.49 and 15.58 g, respectively. In contrary, Hooda and Upaday (2014) reported that kids underwent 50% feed restriction followed by thermal stress could not compensate growth after removal of thermal stress and ad lib. feeding in four months old Alpine × Beetal crossbred kids.

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previously. The DMI/kid/day during restriction phase averaged 494.9, 268.7 and 222.3 g in ad lib. MMFR and MMSFR kids, respectively. The respective DMI during realimentation period ranged from 569.1±5.8 to 723.7±8.1, 371.7±4.8 to 719.6±8.1 g/kid/day. Similar DMI were reported by Sahlu et al. (1999) during restriction and realimentation trials. Suwignyo et al. (2017) recorded mean DMI in control, 30 days feed restriction with 60 days realimentation and 60 days feed restriction with 30 days realimentation in eight months old 60% feed restricted Kacang goat kids of Indonesia as 686.30, 552.26 and 474.73 g, respectively. The total DMI for respective three groups during restriction and realimentation phases were recorded to be 29.70, 16.13, 13.34 and 111.89, 102.87, 103.68 kg. The DMI up to 45 days of feed realimentation was significantly (P<0.01) lower in feed restricted kids and thereafter, it was remained almost equal in all three groups.

The DMI in terms of percentage of body weight in ad lib. kids showed decreasing trend with the advancement of age. During restriction phase, it varied from 4.37 to 5.46, 3.16–3.77 and 3.13 to 2.14% in ad lib. MMFR and MMSFR kids, respectively. During realimentation phase, a sharp increase in DMI was recorded in feed restricted kids. During first 15 days, the increase was to the tune of 31.66 and 66.82% in MMFR and MMSFR kids, respectively and this increasing trend continued up to 60 days of realimentation period. Thereafter, the percent DMI tended to decrease in all the groups. The overall DMI/100 kg during the trial was found to be 4.04, 3.68 and 3.38% in ad lib. fed, MMFR and MMSFR kids, respectively.

Carcass traits: The least squares means and analysis of variance for carcass traits of feed restricted and ad lib. fed Barbari kids (Table 3) revealed that there was no significant difference among groups for any of the carcass traits studied which is in agreement with the reports of Sahlu et al. (1999), Sharma et al. (2009) and Suwignyo et al. (2015) in goats. Similarly, the nonsignificant difference in carcass traits after the end of different levels and duration of restriction and realimentation trial was also observed in lambs (Abouheif et al. 2015, Raju et al. 2015). However, the dressing percentage on live weight basis was marginally higher in ad lib. fed kids and so was on empty live weight basis.

Economics of dietary restriction: The quantity of feed saved in terms of dry matter intake and the cost per kg weight gain due to dietary restriction have been calculated by considering total dry matter intake in different groups during the trial period and the cost of feed. The cost of complete feed (50:50) was calculated as ₹ 1200.00 per quintal considering the present cost of concentrate mixture and dry fodder @ ₹ 1700.00 and

Table 2. Effect of feed restriction and realimentation on dry matter intake (g/kid/day) in Barbari kids

| Period             | ADLIB          | MMFR          | MMSFR         |
|--------------------|----------------|---------------|---------------|
| Feed Restriction Phase |                |               |               |
| 0–10th day        | 362.3 (4.37)   | 252.0 (3.16)  | 252.0 (3.13)  |
| 10–20th day       | 434.8 (4.92)   | 251.9 (3.17)  | 250.9 (3.11)  |
| 20–30th day       | 487.7 (5.22)   | 309.6 (3.77)  | 239.4 (2.95)  |
| 30–40th day       | 531.5 (5.46)   | 265.9 (3.19)  | 241.8 (2.97)  |
| 40–50th day       | 562.1 (5.40)   | 264.5 (3.18)  | 181.0 (2.24)  |
| 50–60th day       | 591.1 (5.32)   | 268.3 (3.19)  | 168.1 (2.14)  |
| Feed Realimentation phase |            |               |               |
| 0–15th day        | 579.4 (4.87)   | 371.7 (4.20)  | 290.9 (3.57)  |
| 15–30th day       | 569.1 (4.48)   | 441.2 (4.60)  | 402.7 (4.55)  |
| 30–45th day       | 597.9 (4.51)   | 468.9 (4.59)  | 495.3 (5.08)  |
| 45–60th day       | 587.1 (4.18)   | 541.2 (4.89)  | 604.2 (5.54)  |
| 60–120th day      | 618.0 (3.83)   | 616.1 (4.53)  | 653.5 (4.66)  |
| 120–175th day     | 723.7 (3.67)   | 702.0 (4.01)  | 719.6 (3.75)  |

Value in parentheses indicates dry matter intake expressed as percentage of body weight.
Table 3. Effect of feed restriction and realimentation on carcass traits in Barbari kids

| Particular          | Least Squares Means±SE | Significance |
|---------------------|------------------------|--------------|
|                     | ADLIB MMFR MMSFR       |              |
| Slaughter weight (kg) | 20.75±1.36 18.86±1.21 20.02± 1.11 | NS           |
| Empty live weight (kg) | 17.82±1.18 16.18±1.01 17.25±0.96 | NS           |
| Carcass weight (kg)  | 9.90±0.72 8.68±0.64 9.45±0.56 | NS           |
| Dressing rate (%)    | 47.52±1.06 46.09±0.95 47.19±0.87 | NS           |
| On live weight basis |                        |              |
| On Empty live weight basis | 55.43±0.87 53.71±0.78 54.62±0.71 | NS           |

ADLIB, ad lib. fed group; MMFR, mild and moderate feed restricted group; MMSFR, mild, moderate and severe feed restricted group; NS, non-significant.

Table 4. Economics of dietary restriction in Barbari kids

| Particular | ADLIB | MMFR | MMSFR |
|------------|-------|------|-------|
| Total DMI/kg (kg) | 141.59 | 119.9 | 117.02 |
| Cost of feed @ ₹ 1200.00/Q DM (₹) | 1699.08 | 1438.8 | 1404.24 |
| Weight gain (kg) | 13.65 | 11.34 | 13.80 |
| Cost/kg weight gain (₹) | 124.47 | 126.88 | 101.76 |
| Feed saved/kg gain (kg) | Basis | 1.91 | 1.78 |
| Cost of feed saved (₹)/kg gain | 22.95 | 21.37 | |
| Cost of feed saved/100 kg gain (₹) | 2295.24 | 2136.52 | |

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REFERENCES

Abouheif M, Al-Sornokh H, Swelum A, Yaqoob H and Al-Owaimer A. 2015. Effect of different feed restriction regimens on lamb performance and carcass traits. *Revista Brasileira de Zootecnia* 44: 76–82.

Agnihotri M K, Rajkumar V and Dutta T K. 2006. Effect of feeding complete rations with variable protein and energy levels prepared using by-products of pulses and oilseeds on carcass characteristics, meat and meat ball quality of goats. *Asian Australasian Journal ofAnimal Sciences* 19: 1437–49.

Babu B S, Suryanarayana M VA N, Rao E R and Latha P A. 2017. Effect of feed restriction on performance and nutrient digestibility in ram lambs. *International Journal of Current Microbiology and Applied Sciences* 6: 566–72.

Dashtizadeh M, Zamiri M J, Kamalzadeh A and Kamali A. 2008. Effect of feed restriction on compensatory growth response of young male goats. *Iranian Journal ofVeterinary Research* 23: 104–20.

Dashtizadeh M, Kamalzadeh A, Sadeghi M H, Kamali A A and Kabirifard A. 2010. The effects of feed restriction severity on compensatory growth of goat kids in Bushehr Province Iran. 5th International Seminar on Tropical Animal Production on Community Empowerment and Tropical Animal Industry, October 19–22, Yogyakarta, Indonesia. p 201–207.

Demir E, Sarica S, Sekeroglu A, Ozcan M A and Seker Y. 2004. Effects of early and late feed restriction or feed withdrawal on growth performance, ascites and blood constituents of broiler chickens. *Acta Agriculturae Scandinavica, Section A - Animal Science* 54: 152–58.

Harvey. 1990. Users guide for LSML MW and MIXMDL PC-2 Version Mixed model Least square and maximum likelihood computer program. Ohio State University, Columbus.

Hooda O K and Upadhyay R C. 2014. Physiological responses, growth rate and blood metabolites Under feed restriction and thermal exposure in kids. *Journal of Stress Physiology and Biochemistry* 10: 214–27.

Kamalzadeh A, Koops W J, van Bruchem J and Bangma G A. 1998. Effect of duration of feed quality restriction on body dimension in lambs. *Journal of Animal Science* 76: 735–42.

Keogh K, Waters S M, Kelly A K and Kenny D A. 2015. Feed restriction and subsequent realimentation in Holstein Friesian bulls: I. Effect on animal performance; muscle, fat, and linear body measurements; and slaughter characteristics. *Journal of Animal Science* 93: 3578–89.

Kumar S, Dutta N, Pattanaik A K, Ojha B K and Chaturvedi V B. 2017. Effect of feed restriction on energy metabolism and methane emission in goats. *Journal of Animal Research* 71: 369–76.

Lee C Y, Lee H P, Jeong J H, Baik K H, Jin S K, Lee J H and Sohn S H. 2002. Effects of restricted feeding, low-energy diet, and implantation of trenbolone acetate plus estradiol on growth, carcass traits, and circulating concentrations of insulin-like growth factor (IGF)-I and IGF-binding protein-3 in finishing barrows. *Journal of Animal Science* 80: 84–93.

Muna M M A and Ammar I E S. 2001. Effect of water and feed restriction on body weight change and nitrogen balance in desert goats fed with high and low quality forages. *Small Ruminant Research* 41: 19–27.

Ojha B K, Dutta N and Pattanaik A. 2018. Effect of feed restriction on nutrient utilization, growth and metabolic profile in crossbred calves. *Indian Journal of Animal Sciences* 88: 99–104.

ACKNOWLEDGEMENTS

We are grateful to the Director of the Institute for providing necessary facilities and Sh Dinesh Bhatt, Radhey Shyam and Mohd. Sarfaraz for their technical assistance.
Raju S, Reddy Y R, Nagalakshmi D and Raghunandhan T. 2015. Effect of supplementation of dietary protected lipids at varying levels of feed restriction on growth performance and carcass characteristics in Deccani ram lambs. *Animal Nutrition and Feed Technology* 15: 439–46.

Ryan W J, Williams I H and Moir R J. 1993. Compensatory growth in sheep and cattle. II. Changes in body composition and tissue weights. *Australian Journal of Agriculture Research* 44: 1609–21.

Sahlu T, Hart S P and Goetsch A L. 1999. Effect of level of feed intake on body weight, body components and mohair growth in Angora goats during re-alimentation. *Small Ruminant Research* 32: 251–59.

Salem O A I, El-Gallard T T, Allam S M, Hassouna and Farghly M S. 1989. Effects of periodic feed restriction with subsequent re-alimentation on performance of Baladi goats. *Small Ruminant Research* 2: 133–41.

Sharma R B, Das A K, Singh D, Ramachandran N, Kumar P and Singh N P. 2009. Effect of dietary restriction and realimentation on carcass characteristics in Sirohi goat kids. *Indian Journal of Animal Sciences* 79: 198–201.

Suwignyo B, Baihaqi Z A, Utomo R, Sarmin and Widiyono I. 2017. Effects of different feed restrictions on Kacang goats. *Pakistan Journal of Nutrition* 16: 236–41.

Suwignyo B, Haq M S, Setiyono and Suryanto E. 2015. Restriction feed and refeeding evaluation for consumption, feed cost, income over feed cost, percentage of carcass and meat quality in Kacang goats. 6th International Seminar on Tropical Animal Production on integrated approach in developing sustainable Tropical Animal production October 20–22, Yogyakarta, Indonesia. p 191–197.

Thornton R F, Hood R L, Jones P N and Re V M. 1979. Compensatory growth in sheep. *Australian Journal of Agriculture Research* 30: 135–51.

Vyas D, Gangil D, Singh R and Tripathi R. 2012. Effect of restricted milk feeding on the growth of goat kids before weaning. *Indian Journal of Animal Production and Management* 28: 227–29.