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Impact of ancillary housing structure on body morphometric traits and skin fold thickness of winter-born black Bengal goat kids

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Abstract
This present investigates the influence of the ancillary housing structure (kid barrel) on the morphometric traits and skin fold thickness of Black Bengal goat kids during pre-weaning and post-weaning periods. For this study, pregnant Black Bengal does with similar breeding history and parity were selected and housed within the same shelter. Following the birth of the kids (n=12), they were randomly assigned to the control (n=6) and experiment (n=6) groups, alongside their respective mothers. The housing conditions for the control and experimental kids were generally the same, except for the experimental group which had access to a specially designed housing ancillary structure (kid barrel) that only allowed entry and exit for the kids, excluding the adults. Pre-weaning ($P<0.01$) and post-weaning weaning ($P<0.05$) corpus length was significantly higher in kids of the experimental group than in the control group. Pre-weaning body length was significantly ($P<0.001$) higher in the experimental group than in the control group. Similarly, pre-weaning and post-weaning traits *viz.* heart girth, rear girth, height at back, and height at wither were significantly ($P<0.01$) higher in kids of the experimental group than in the control group. Pre-weaning skin fold thickness (SFT) of the shoulder ($P<0.05$) and post-weaning SFT of the flank ($P<0.05$) and brisket ($P<0.01$) was significantly higher in kids of the experimental group than in the control group. We concluded that provision of ancillary housing structure (kid barrel) significantly influenced the body morphometric traits and skin fold thickness of the winter-born goat kids during both the pre-weaning and post-weaning stages. This study contributes valuable insights into the management practices for winter-born Black Bengal goat kids and emphasizes the importance of suitable housing structures (kid barrel) in enhancing their body morphometric traits and skin fold thickness.

Keywords: Goat kids, kid barrel, morphometric traits, skin fold thickness, winter

1. Introduction

The Black Bengal goat is a small-sized and highly adaptable breed native to eastern and northern parts of India and entire Bangladesh. This breed has exceptional tolerance to harsh climatic conditions and the breed is well-suited to challenging terrains and extreme temperatures (Rahman *et al.*, 2016; Nath *et al.*, 2014) [1, 2]. Their adaptability, resilience, and economic significance have made them a popular choice for small-scale and subsistence farmers, contributing to sustainable livelihoods and rural development in the regions where they are reared (Devendra, 2013; Hossain, 2021) [3, 4]. The rearing environment plays a crucial role in the growth and development of goats, directly influencing their overall health, well-being, and productivity. Among the various factors contributing to the rearing environment, housing conditions have been recognized as key determinants of the growth, development, and overall well-being of goat kids.

Winter-born goat kids require good warm housing due to several physiological and thermoregulatory factors. During the early stages of life, goat kids have limited fat reserves and a high surface area-to-body weight ratio, making them more susceptible to heat loss and cold stress (Mellor and Stafford, 2004) [5]. In cold environments, exposure to low temperatures leads to increased energy expenditure for maintaining body temperature, potentially compromising growth and overall health (Lima *et al.*, 2022) [6]. The inclement winter season exerts a pronounced and deleterious impact on the well-being of goat kids, leading to an elevated incidence of morbidity and mortality (Kashem *et al.*, 2012; Tudu and Goswami, 2015; Das *et al.*, 2022a) [7, 8, 9]. Adequate warm housing provides insulation against the cold, reduces heat loss, and helps conserve energy, allowing winter-born goat kids to allocate their resources towards growth and development, ensuring their well-being and survival during the critical pre- and post-weaning period (Das *et al.*, 2022a) [9].

During the pre-weaning period goat kids are particularly vulnerable and require a suitable housing condition that offers protection against extreme weather situations, enabling their growth, health, and survival (Dwyer *et al.,* 2016 [10]). Adequate housing during winter provides insulation, and protection against harsh elements, and minimizes heat loss, allowing goat kids to conserve energy and allocate resources towards growth, immune system development, and overall health. However, limited research has been conducted to investigate the precise effects of ancillary housing structures during winter (like kid barrel in the present study) on body morphometric traits and skin fold thickness during the pre-and post-weaning stages of black Bengal goat kids.

For several reasons, it is essential to know how ancillary housing structures affect body morphometric traits and skin fold thickness of goat kids. Firstly, it helps identify the optimal housing conditions that facilitate optimal growth and development, ensuring better productivity and overall animal welfare. Secondly, assessing body measurements and skin fold thickness during the pre-and post-weaning periods provides valuable insights into the effectiveness of various housing structures and guides improvements in management practices. Therefore, this study aims to investigate the effect of different ancillary housing structures on body morphometric traits and skin fold thickness of winter-born Black Bengal goat kids during the pre-and post-weaning periods. By evaluating parameters such as linear body traits and skin fold thickness, we aim to elucidate the relationship between ancillary housing structure and the physical development of Black Bengal goat kids.

2. Materials and methods

The study was carried out at the Experimental Goat Shed located at ICAR-National Dairy Research Institute, Eastern Regional Station (ERS), Kalyani, West Bengal, India. The animal trial duration was from December 2021 to April 2022. For the current investigation, pregnant Black Bengal does were chosen based on their breeding history, obtained from the Goat Unit ICAR-NDRI, ERS, Kalyani. After parturition, the kids and their mothers were randomly assigned to two groups. Each group consisted of six kids, comprising four males and two females. During the selection process of the newborn kids, meticulous attention was given to minimizing errors by narrowing down the age and birth weight range of these experimental kids as much as possible.

All animals (dams and kids) were reared within an intensive housing system. A shared shelter with a total area of 200 square feet was divided into two equal parts (100 square feet each) using bamboo fences, alongside an open paddock with a concrete floor (120 square feet). The control and experimental groups were housed separately in each partition. Both pens featured an asbestos roof and a cement-concrete floor surface. The housing conditions for the control and experimental kids were generally the same, except for the experimental group which had access to a specially designed housing ancillary structure (kid barrel) that only allowed entry and exit for the kids, excluding the adults (Fig 1). The floor of the kid barrel was filled with chopped paddy straw as bedding material. In the control groups, the kids were provided with gunny bags and paddy straw as bedding material over the concrete floor, following the routine management practices of the farm. Kids were allowed to suck freely and suckling was continued until weaning (60 days). From the second week onwards, a palatable and easily digestible concentrate mixture and seasonal green fodder were offered separately to the kids of both groups. When the kids started to increase their feed intake at the age of 2 months, they were weaned. During the post-weaning period, kids were fed concentrate mixture and seasonal green fodders (mustard, oats, berseem, and para grass). Clean drinking water was provided ad libitum during the experimental period. Following a 0-60 days suckling period, the dams were separated from the kids. The respective groups of kids were then kept in their allocated pens for an additional 61-120 days to observe their post-weaning performance.

The housing ancillary structure (kid barrel) was constructed using a wooden framework enclosed with wire netting, featuring an upward curvature. The wire netting was coated with straw and covered with polythene to secure the straw in place. Additionally, a layer of wire netting was added to prevent the kids and their mothers from biting the polythene. The floor of the kid barrel was prepared using wooden plates with intentional gaps of approximately 1 cm between them to facilitate the unobstructed flow of urine. Chop straw was also provided on the floor surface of the kid barrel. The design of the kid barrel was specifically tailored to allow only the kids to enter and exit freely, ensuring their unrestricted movement within the barrel. The dimension of the kid barrel is 100 cm (L), 65 cm (H), and 65 cm (W).

The external body morphometric traits *viz.* corpus length, body length, height at withers, height at back (rump height), chest girth (heart girth), paunch girth (rear girth), and subcutaneous skin thickness at shoulder, flank, and brisket area were recorded at fortnightly intervals (Sowande *et al.*, 2010) [11] before feeding and watering. The body measurements and skin fold thickness were taken with the help of measuring tape and digital vernier caliper, while the kids were made to stand on a leveled floor with their head held up. The parameters observed were as follows:

(a) Corpus length (CL): It is the distance from the base of the ear to the base of the tail (i.e., last sacrum/ where the body meets).

(b) Body length (BL); It is the distance from the point of the shoulder to the point of the tuber ISCHII.

(c) Height at withers: It is the distance from the base of the hoof of the foreleg to the highest point of the withers.

(d) Height at back: It is the distance from the base of the hoof of the hindleg to the Tubercoxae.

(e) Heart girth (HG): It is the circumferential measure taken around the chest just behind the elbow joint.

(f) Rear girth (RG): It is measured as the body circumference in front of the sacrum.

(g) Subcutaneous skin thickness or skin fold thickness (SFT): It is the skin fold thickness of the body from different parts *viz.* shoulder, flank, and brisket region.

The data were subjected to analysis using the SPSS software version 26.0. The statistical approach employed for data analysis involved the utilization of the univariate General Linear Model (GLM). Means exhibiting significance difference were further examined through post-hoc comparisons utilizing Duncan's multiple range test, with significance determined at a level of $P<0.05$ and $P<0.01$.

3. Results and discussion

Different body morphometric traits *viz.* corpus length, body length, height at withers, height at back (rear height), chest girth (heart girth), paunch girth (rear girth), and subcutaneous skin thickness were recorded at fortnightly intervals and presented in T
able 1, 2, 3, 4, 5, 6, 7, 8 and 9.

Body morphometric traits

Table 1 shows the pre-and post-weaning fortnightly corpus length (cm) of kids in different groups. Pre-weaning fortnightly corpus length of kids was affected by group

($P<0.01$) and fortnight ($P<0.001$) but not affected by group × fortnight interaction. Pre-weaning corpus length was significantly higher in kids of the experimental group than in the control group (T_1= 46.89±1.14 cm; T_0= 43.91±1.10 cm). Post-weaning fortnightly corpus length was affected by the group ($P<0.05$) but not by the fortnight and group × fortnight interaction. Post-weaning corpus length was significantly higher in kids from the experimental group than in the control group (T_1= 58.31±0.72 cm; T_0= 55.33±0.93 cm).

Pre-and post-weaning fortnightly body length (cm) of kids in different groups are presented in Table 2. The pre-weaning fortnightly body length of kids was affected by group ($P<0.001$) and fortnight ($P<0.001$) but not affected by group × fortnight interaction. Pre-weaning body length was significantly higher in the experimental group than in the control group (T_1= 33.39±0.70 cm; T_0= 30.58±0.77 cm). The post-weaning fortnightly corpus length of kids was not affected by group fortnight and group × fortnight interaction.

Pre-and post-weaning fortnightly heart girth (cm) of kids in different groups are presented in Table 3. Pre-weaning fortnightly heart girth of kids was affected by group ($P<0.01$) and fortnight ($P<0.001$) but not affected by group × fortnight interaction. Pre-weaning heart girth was significantly higher in kids of the experimental group than in the control group (T_1= 36.41±0.71 cm; T_0= 34.50±0.72 cm). Post-weaning fortnightly heart girth of kids was affected by group ($P<0.01$) but not affected by fortnight and group × fortnight interaction. Post-weaning heart girth was significantly higher in kids of the experimental group than in the control group (T_1= 43.67±0.49 cm; T_0= 41.04±0.70 cm).

Pre-and post-weaning fortnightly rear girth (cm) of kids in different groups are presented in Table 4. The pre-weaning fortnightly rear girth of kids was affected by group ($P<0.001$) and fortnight ($P<0.001$) but not affected by group × fortnight interaction. The pre-weaning rear girth was significantly higher in kids of the experimental group than in the control group (T_1= 38.20±1.05 cm; T_0= 35.31±1.05 cm). The post-weaning fortnightly rear girth of kids was affected by group ($P<0.05$) but not by fortnight and group × fortnight interaction. The post-weaning rear girth was significantly higher in kids of the experimental group than in the control group (T_1= 49.00±0.68 cm; T_0= 46.52±0.85 cm).

Pre-and post-weaning fortnightly height at back (cm) of kids in different groups are presented in Table 5. Pre-weaning fortnightly height at back of kids was affected by group ($P<0.01$) and fortnight ($P<0.001$) but not affected by group × fortnight interaction. Pre-weaning height at back was significantly higher in kids of the experimental group than in the control group (T_1=33.27±0.58 cm; T_0= 32.08±0.46 cm). Post-weaning fortnightly height at back of kids was affected by group ($P<0.01$) but not affected by fortnight and group × fortnight interaction. Post-weaning height at back was significantly higher in kids of the experimental group than in the control group (T_1= 40.64±0.47 cm; T_0= 38.00±0.57 cm).

Pre-and post-weaning fortnightly height at wither (cm) of kids in different groups are presented in Table 6. Pre-weaning fortnightly height at wither of kids was affected by group ($P<0.001$) and fortnight ($P<0.001$) but not affected by group × fortnight interaction. Pre-weaning height at wither was significantly higher in kids of the experimental group than in the control group (T_1= 32.68±0.63 cm; T_0= 30.89±0.53 cm). Post-weaning fortnightly height at wither of kids was affected by group ($P<0.01$) but not affected by the fortnight and group × fortnight interaction. Post-weaning height at wither was significantly higher in kids of the experimental group than in the control group (T_1= 40.22±0.49 cm; T_0= 37.72±0.59 cm).

The body morphometric parameters of winter-born goat kids were higher for those reared in kid barrel compared to those without kid barrel due to the thermoregulatory benefits provided by the insulation. Several genetic and non-genetic factors (Kumar *et al.*, 2012) [12], including polymorphisms in the growth hormone (GH) gene (Dayal *et al.*, 2016) [13], seasons (Mandal *et al.*, 2022a) [14], as well as behavioral factors such as mother-kid interactions (Das *et al.*, 2022b; Mandal *et al.*, 2022b) [15, 16], have been reported to exert an influence on the growth performance of Black Bengal goat. Khan *et al.* (2006) [17], Pesmen and Yardimci (2008) [18], and Iqbal *et al.* (2013) [19] have collectively observed a favorable positive correlation between body weight and the different body morphometric parameters of young goat kids. Khan *et al.* (2006) [17], Rahman *et al.* (2008) [1], Mule *et al.* (2014) [20], and Antil *et al.* (2019) [21] reported a congruent and progressive augmentation in the body morphometric parameters of young goat kids, corresponding to the incremental advancement in age. Cold temperatures during winter increase the energy expenditure required to maintain body temperature, potentially compromising growth and development. Providing a warm environment through the kid barrel helps minimize heat loss, reduce cold stress, and allow the goat kids to conserve energy for growth instead of thermoregulation. This improved energy allocation promotes better nutrient utilization, increased feed intake, and optimal growth, resulting in higher body morphometric parameters for the winter-born goat kids reared in kid barrel.

Skin fold thickness (SFT)

Pre-and post-weaning fortnightly SFT of flank (mm) of kids in different groups are presented in Table 7. Pre-weaning fortnightly SFT of the flank of kids was not affected by group and group × fortnight interaction but affected by fortnight ($P<0.01$). However, post-weaning fortnightly SFT of the flank of kids was affected by group ($P<0.05$) but not affected by fortnight and group × fortnight interaction. Post-weaning SFT of the flank was significantly higher in kids of the experimental group than in the control group (T_1= 2.84±0.07 mm; T_0= 2.54±0.07 mm).

Pre-and post-weaning fortnightly SFT of the shoulder (mm) of kids in different groups are presented in Table 8. Pre-weaning fortnightly SFT of the flank of kids was affected by group ($P<0.05$) but not by fortnight and group × fortnight interaction. Pre-weaning SFT of the shoulder was significantly higher in kids of the experimental group than in the control group (T_1= 2.64±0.05 mm; T_0= 2.41±0.08 mm). Post-weaning fortnightly SFT of the shoulder of kids was not affected by group, fortnight, and group × fortnight interaction.

Pre-and post-weaning fortnightly SFT of brisket (mm) of kids in different groups were presented in Table 9. Pre-weaning fortnightly SFT of brisket of kids was not affected by group, fortnight and group × fortnight interaction. However, post-weaning fortnightly SFT of shoulder of kids was affected by group ($P<0.01$) but not affected by fortnight and group × fortnight interaction. Post-weaning SFT of brisket was significantly higher in kids of the experimental group than in the control group (T_1= 3.35±0.17 mm; 2.75±0.08 mm).

The skin fold thickness of winter-born goat kids was higher for those reared kid barrel compared to those without kid barrel due to the thermal benefits provided by the insulation. Significant variations in skin thickness among strains of Merino sheep have also been reported by Murray (1996) [22] and Williams and Thornberry (1992) [23] suggested that diet and climatic conditions influenced skin thickness. Skin thickness variations in goats are not well documented; however, there have been significant differences in skin thickness among Merino sheep in different body locations (Wodzicka, 1958 [24]; Williams and Thornberry, 1992 [23]). Cold temperatures during winter lead to vasoconstriction and reduced blood flow to the skin, resulting in decreased skin fold thickness. However, the kid barrel creates a controlled microclimate that helps maintain a warmer environment. This promotes vasodilation and increased blood flow to the skin, leading to higher skin fold thickness. The insulation in the hutch prevents excessive heat loss and cold stress, allowing the goat kids to maintain better peripheral circulation and thicker skin folds, which indicates improved thermal regulation and overall welfare of goat kids.

Table 1: Fortnightly pre- and post-weaning corpus length (Mean ± SE) of kids in different groups

Corpus length (cm)	Fortnight	Control (T_0)	Experiment (T_1)	Fortnight mean
Pre-weaning	I	37.75±0.68	39.66±0.84	38.70^{w}±0.59
	II	42.83±1.26	45.16±1.18	44.00^{x}±0.89
	III	45.75±1.86	50.00±0.93	47.87^{y}±1.18
	IV	49.33±1.56	52.75±1.15	51.04^{z}±1.06
	Overall	43.91^{a}±1.10	46.89^{b}±1.14	-
P value	Group	0.002		
	Fortnight	0.000		
	Group × Fortnight	0.780		
Post-weaning	V	53.58±1.81	56.25±1.06	54.91±1.08
	VI	54.08±1.93	56.91±1.33	55.50±1.20
	VII	56.58±1.80	59.66±1.31	58.12±1.16
	VIII	57.08±1.98	60.41±1.61	58.75±1.31
	Overall	55.33^{A}±0.93	58.31^{B}±0.72	-
P value	Group	0.014		
	Fortnight	0.060		
	Group × Fortnight	0.997		

Row wise means with different superscripts differ significantly; a, b significant *P*<0.01; A, B significant *P*<0.05; Column wise means with different superscripts (w, x, y, z) differ significantly

Table 2: Fortnightly pre- and post-weaning body length (Mean ±SE) of kids in different groups

Body length (cm)	Fortnight	Control (T_0)	Experiment (T_1)	Fortnight mean
Pre-weaning	I	26.66^{a}±0.47	29.91^{b}±0.55	28.29^{x}±0.60
	II	29.33±1.30	32.08±1.04	30.70^{y}±0.89
	III	32.58±1.27	35.00±1.25	33.79^{z}±0.92
	IV	33.75±1.09	36.58±0.94	35.16^{z}±0.81
	Overall	30.58^{a}±0.77	33.39^{b}±0.70	-
P value	Group	0.000		
	Fortnight	0.000		
	Group × Fortnight	0.983		
Post-weaning	V	36.83±1.42	38.17±1.19	37.50±0.90
	VI	37.66±1.38	38.75±1.26	38.20±0.90
	VII	38.08±1.50	39.66±1.07	38.87±0.91
	VIII	38.83±1.69	40.16±1.05	39.50±0.97
	Overall	37.85±0.71	39.18±0.56	-
P value	Group	0.167		
	Fortnight	0.488		
	Group × Fortnight	0.998		

Row wise means with different superscripts differ significantly; a, b significant *P*<0.01; Column wise means with different superscripts (y, z) differ significantly

Table 3: Fortnightly pre- and post-weaning heart girth (Mean ± SE) of kids in different groups

Heart girth (cm)	Fortnight	Control (T_0)	Experiment (T_1)	Fortnight mean
Pre-weaning	I	30.33^{A}±0.51	31.91^{B}±0.43	31.12^{x}±0.39
	II	34.00±1.09	36.75±0.60	35.37^{y}±0.72
	III	36.08^{a}±1.13	37.91^{b}±0.50	37.00^{yz}±0.65
	IV	37.58±1.01	39.08±1.59	38.33^{z}±0.93
	Overall	34.50^{a}±0.72	36.41^{b}±0.71	-
P value	Group	0.007		
	Fortnight	0.000		
	Group × Fortnight	0.907		
Post-weaning	V	40.91±1.35	43.25±0.84	42.08±0.83
	VI	40.25±1.30	42.10±0.89	41.17±0.80
	VII	41.16±1.40	44.33±1.04	42.75±0.96
	VIII	41.83±1.81	45.00±0.95	43.41±1.08
	Overall	41.04^{a}±0.70	43.67^{b}±0.49	-
P value	Group	0.005		
	Fortnight	0.326		
	Group × Fortnight	0.937		

Row wise means with different superscripts differ significantly; a, b significant *P*<0.01; A, B significant *P*<0.05; Column wise means with different superscripts (x, y, z) differ significantly

Table 4: Fortnightly pre- and post-weaning rear girth (Mean ± SE) of kids in different groups

Rear girth (cm)	Fortnight	Control (T_0)	Experiment (T_1)	Fortnight mean
Pre-weaning	I	28.91±0.75	31.08±0.76	30.00^x±0.60
	II	34.83^A±1.07	37.75^B±0.40	36.29^y±0.70
	III	36.08^A±0.96	39.66^B±0.95	37.87^y±0.84
	IV	41.41±1.38	44.33±0.86	42.87^z±0.89
	Overall	35.31^a±1.05	38.20^b±1.05	-
P value	Group	0.000		
	Fortnight	0.000		
	Group×Fortnight	0.901		
Post-weaning	V	45.25±1.22	48.08±1.07	46.66±0.88
	VI	45.50±1.91	46.91±1.13	46.20±1.08
	VII	47.00±1.40	50.50±1.35	48.75±1.07
	VIII	48.33±2.23	50.50±1.58	49.41±1.34
	Overall	46.52^A±0.85	49.00^B±0.68	-
P value	Group	0.028		
	Fortnight	0.120		
	Group × Fortnight	0.917		

Row wise means with different superscripts differ significantly; a, b significant *P*<0.01; A, B significant *P*<0.05; Column wise means with different superscripts (x, y, z) differ significantly

Table 5: Fortnightly pre- and post-weaning height at back (Mean ± SE) of kids in different groups

Height at back (cm)	Fortnight	Control (T_0)	Experiment (T_1)	Fortnight mean
Pre-weaning	I	29.75±0.51	30.00±0.46	29.87^w±0.33
	II	31.25±0.54	31.91±0.15	31.58^x±0.28
	III	32.41^A±0.45	34.16^B±0.33	33.29^y±0.37
	IV	34.91±0.62	37.00±0.71	35.95^z±0.55
	Overall	32.08^a±0.46	33.27^b±0.58	-
P value	Group	0.002		
	Fortnight	0.000		
	Group × Fortnight	0.231		
Post-weaning	V	37.08±0.95	39.58±0.77	38.33±0.69
	VI	37.25±0.91	40.16±1.06	38.70±0.80
	VII	37.91±1.36	41.00±0.92	39.45±0.91
	VIII	39.75±1.28	41.83±1.01	40.79±0.84
	Overall	38.00^a±0.57	40.64^b±0.47	-
P value	Group	0.001		
	Fortnight	0.113		
	Group × Fortnight	0.965		

Row wise means with different superscripts differ significantly; a, b significant *P*<0.01; A, B significant *P*<0.05; Column wise means with different superscripts (w, x, y, z) differ significantly

Table 6: Fortnightly pre- and post-weaning height at wither (Mean ± SE) of kids in different groups

Height at withers (cm)	Fortnight	Control (T_0)	Experiment (T_1)	Fortnight mean
Pre-weaning	I	28.58±0.80	29.00±0.46	28.79^w±0.44
	II	29.91±0.74	31.16±0.40	30.54^x±0.44
	III	31.00^a±0.56	33.91^b±0.32	32.45^y±0.53
	IV	34.08^A±0.61	36.66^B±0.60	35.37^z±0.56
	Overall	30.89^a±0.53	32.68^b±0.63	-
P value	Group	0.000		
	Fortnight	0.000		
	Group × Fortnight	0.131		
Post-weaning	V	36.9±1.03	39.08±0.77	38.00±0.69
	VI	37.00±1.05	39.58±1.10	38.29±0.82
	VII	37.75±1.20	40.66±0.90	39.20±0.84
	VIII	39.25±1.44	41.83±1.01	40.41±0.91
	Overall	37.72^a±0.59	40.22^b±0.49	-
P value	Group	0.002		
	Fortnight	0.128		
	Group × Fortnight	0.987		

Row wise means with different superscripts differ significantly; a, b significant *P*<0.01; A, B significant *P*<0.05; Column wise means with different superscripts (w, x, y, z) differ significantly

Table 7: Fortnightly pre- and post-weaning SFT of flank (Mean ± SE) of kids in different groups

SFT of flank (mm)	Fortnight	Control (T_0)	Experiment (T_1)	Fortnight mean
Pre-weaning	I	2.91±0.07	2.95±0.20	2.93^z±0.10
	II	2.39±0.09	2.60±0.20	2.50^y±0.11
	III	2.21±0.12	2.44±0.15	2.33^y±0.10
	IV	2.35±0.80	2.62±0.11	2.48^y±0.07
	Overall	2.47±0.07	2.65±0.08	-
P value	Group	0.069		
	Fortnight	0.001		
	Group × Fortnight	0.852		
Post-weaning	V	2.58±0.12	2.56±0.06	2.57±0.06
	VI	2.57±0.12	2.85±0.15	2.71±0.10
	VII	2.61±0.18	2.99±0.12	2.80±0.12
	VIII	2.41±0.18	2.94±0.21	2.68±0.15
	Overall	2.54^A±0.07	2.84^B±0.07	-
P value	Group	0.011		
	Fortnight	0.511		
	Group × Fortnight	0.360		

Row wise means with different superscripts differ significantly; A, B significant $P<0.05$; Column wise means with different superscripts (y, z) differ significantly

Table 8: Fortnightly pre- and post-weaning SFT of shoulder (Mean ± SE) of kids in different groups

SFT of shoulder (mm)	Fortnight	Control (T_0)	Experiment (T_1)	Fortnight mean
Pre-weaning	I	2.55±0.20	2.59±0.16	2.57±0.12
	II	2.24±0.09	2.48±0.06	2.36±0.06
	III	2.30^a±0.10	2.80^b±0.80	2.55±0.09
	IV	2.57±0.24	2.70±0.07	2.64±0.12
	Overall	2.41^A±0.08	2.64^B±0.05	-
P value	Group	0.029		
	Fortnight	0.259		
	Group × Fortnight	0.420		
Post-weaning	V	2.61±0.13	2.87±0.74	2.74±0.09
	VI	2.84±0.42	2.86±0.18	2.85±0.22
	VII	2.57±0.14	2.87±0.14	2.72±0.10
	VIII	2.63±0.16	2.95±0.13	2.79±0.11
	Overall	2.66±0.11	2.89±0.07	-
P value	Group	0.124		
	Fortnight	0.920		
	Group × Fortnight	0.875		

Row wise means with different superscripts differ significantly; a, b significant $P<0.01$; A, B significant $P<0.05$

Fig 1: Inside view of experimental goat shed (A) and ancillary housing structure (B)

Table 9: Fortnightly pre- and post-weaning SFT of brisket (Mean ± SE) of kids in different groups

SFT of brisket (mm)	Fortnight	Control (T_0)	Experiment (T_1)	Fortnight mean
Pre-weaning	I	2.98±0.31	3.26±0.32	3.12±0.22
	II	2.65±0.23	3.07±0.26	2.86±0.18
	III	2.37±0.14	2.82±0.26	2.59±0.15
	IV	2.85±0.10	2.90±0.17	2.87±0.09
	Overall	2.72±0.11	3.00±0.12	-
P value	Group	0.111		
	Fortnight	0.205		
	Group × Fortnight	0.716		
Post-weaning	V	2.80±0.21	2.85±0.13	2.82±0.12
	VI	2.64±0.19	3.18±0.26	2.91±0.17
	VII	2.71^A±0.14	3.71^B±0.31	3.21±0.22
	VIII	2.85±0.17	3.65±0.50	3.25±0.28
	Overall	2.75^a±0.08	3.35^b±0.17	-
P value	Group	0.003		
	Fortnight	0.300		
	Group × Fortnight	0.340		

Row wise means with different superscripts differ significantly; a, b significant P<0.01; A, B significant P<0.05

4. Conclusion

It was concluded that the ancillary housing structure (kid barrel) significantly influenced the body morphometric traits and skin fold thickness of the winter-born goat kids during both pre- and post-weaning stages. The findings highlight the importance of providing appropriate ancillary housing structures during winter to ensure the optimal growth and development of winter-born goat kids. This study contributes valuable insights into the management practices for winter-born Black Bengal goat kids and emphasizes the significance of suitable housing structures in enhancing their body morphometric traits and skin fold thickness. Further research in this area could explore additional factors that may influence the growth and development of goat kids and help in developing comprehensive management strategies for maximizing their productivity and welfare.

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