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An assessment on the impact of weaning stress on the weaning age in Black Bengal goat kids

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ABSTRACT

Weaning is stressful for goat kids, often leading to stunted growth, weight loss, and mortality, with varied weaning times reducing overall productivity and profitability. The aim of this research was to determine the optimal age for weaning of Black Bengal goat (BBG) kids and evaluate the impact of weaning stress on their post-weaning performances. A trial was conducted comprising 4 groups (8 kids/group), accompanied by 4 lactating does, weaned at intervals of 45, 60, 75, and 90 days (designated as A, B, C, and D, respectively), and reared up to six months of age. Heart rate measurements and blood samplings were done three days before (-3), during (0), and three days after (+3) individual weaning schedules. Furthermore, dry matter intake, daily weight gain, weaning weight, 06 months weight, disease incidence, and kid mortality were also recorded. The serum concentration of triiodothyronine (T3) hormone declined significantly ($p<0.05$) at +3 days after weaning than -3 days before weaning in groups A, B, and C while an increase was observed in group D. The average cortisol level was significantly ($p< 0.05$) lower in group D than in other groups. Post-weaning performances, including weaning weight, 06 months weight, daily weight gain, and kid mortality also differ significantly ($p<0.05$). Group D demonstrated superior performance compared to groups A, B, and C. The findings revealed that kids weaned at 75 to 90 days experienced less stress, performed better, and had fewer health issues.

INTRODUCTION

Bangladesh possesses a huge population of ruminant livestock, specifically, goats account for a remarkable total of 26.945 million [1]. Currently, goat farming is gaining popularity in Bangladesh to meet the increasing demand for animal protein, despite the hot and humid conditions of the country appearing to favor many diseases [2]. About 90% of goats belong to the Black Bengal breed [3, 4], which possess distinct characteristics that set them apart, including their remarkable ability to reproduce, their high fertility rates, their early onset of sexual maturity, their capacity to adapt to hot and humid environments, and the exceptional quality of their meat and skin [5, 6, 7]. Goat rearing is one of the major agricultural activities in the village areas of Bangladesh, which is conducted under a subsistence farming system. Commercial goat farming in intensive or semi-intensive settings is gaining popularity among medium and large farms. The standardization of various goat husbandry procedures is necessary for goat production under stall-fed or semi-intensive circumstances.

Weaning, an unavoidable husbandry practice, typically results in the occurrence of weaning shock. The process of weaning is typically a challenging phase in a kid's life, sometimes accompanied by a reduction in weight gain, a cessation of growth, and, in certain instances, even weight loss [8, 9, 10], which is commonly known as weaning shock. There are several potential factors that could contribute to the observed

phenomenon, including the weakening of the relationship between the dam and the kid, a transition from a diet mostly consisting of nutritious milk to solid feed, inadequate consumption of feed, gradual depletion of bodily reserves, compromised immune function, and the proliferation of opportunistic microorganisms [11, 12]. The outcomes of the post-weaning period are contingent upon various factors, including the feeding regimen implemented before weaning, the physical condition of the offspring, and their age and weight during the pre-weaning phase. These implications can extend for up to two months following the weaning process [12, 13]. The significance of weaning weight at the time of weaning surpasses that of age to mitigate the effects of weaning shock. Birth weight range lower than 1.5 kg had a higher mortality rate of 28.3% for Black Bengal goat (BBG) kids from birth to three months of age [14].

Animals have been observed to display behavioral and physiological reactions in response to acute stress circumstances [15, 16]. These behavioral features serve as the primary and visible parameters. In addition to evaluating behavioral traits, blood hormone levels are employed to evaluate animal well-being and stress levels [17, 18]. Stress leads to an elevation in cortisol levels, a suppression of thyroid hormone release, and an interruption of growth and development [19, 20]. It is widely acknowledged that thyroid hormones have the capacity to enhance oxygen consumption within the body and elevate body temperature. Thyroxine (T4) is the predominant hormone secreted by the thyroid gland. The conversion of T4 to triiodothyronine (T3) occurs in somatic cells, and as a result, the concentration of T4 serves as an indicator of the biochemical capacity for T3 transformation [21]. The assessment of stress levels in animals involves monitoring the hormones cortisol, T3, and T4 [22, 23]. The immune system has been observed to experience suppression in the presence of stress [24, 25, 26]. The level of stress experienced by individuals might differ depending on factors such as the age at which weaning occurs and the ability to consume feeds other than dam's milk [27, 28]. The weaning period is a crucial stage in a kid's upbringing, characterized by a reduction or cessation of weight gain. The magnitude and manifestation of stress during the process of weaning are contingent upon various parameters, with particular emphasis on the age, body weight, and pre-weaning nutritional status of the offspring [29]. In the context of Bangladesh, it is commonly observed among goat farmers that there is a notable deceleration in development or complete retardation of growth, and in certain instances, even weight loss, following the weaning of kids. The mortality rate of kids experiences an upward trend throughout the transitional phase from pre-weaning to post-weaning, hence hindering farmers from attaining maximum profitability in goat farming. Despite the absence of comprehensive data, the issue of weaning shock and its consequential adverse impacts represents a significant challenge in the context of BBG production in Bangladesh. This study aimed to identify the most favorable age for weaning and evaluate the weaning stress on the following performance of BBG kids.

MATERIALS AND METHODS

Study site and duration

The experiment was carried out at the Goat Research Farm in Bangladesh Livestock Research Institute (BLRI), Savar, Dhaka-1341, Bangladesh, from July 2018 to June 2020.

Ethical statement

The Animal Experimentation Ethics Committee of Bangladesh Livestock Research Institute (BLRI) approved this research project (Reference no.: AEEC/ BLRI00104/2023). During sample collection, all the guidelines for animal care were carefully followed.

Animal selection and group allocation

A study was undertaken consisting of four distinct groups (A, B, C, and D) comprising eight kids in each group. Additionally, four lactating female goats were included in the study, where each group consisted of one lactating female goat and two kids (one male and one female). The birth weight of the kids in various groups had a comparable distribution. The kids belonging to various treatment groups were subjected to varied weaning ages following the birth of the kids. These ages were specifically set at 45, 60, 75, and 90 days, and were represented by the groups A, B, C, and D, respectively. The kids were then raised until they reached the age of six months. The control group in this study was designated as Group D.

Housing and feeding of animals

The animals were housed in separate enclosures featuring slatted flooring, ensuring optimal hygiene and adhering to appropriate biosecurity measures. The feeding protocol was consistent across all groups, wherein kid individuals were permitted to remain in the presence of their mothers and engage in suckling behavior. After weaning, kids were fed *ad libitum* maize fodder and a concentrated mixture at the rate of 1.5% of their body weight and reared in an individual pen. The composition of concentrate feed was 30% of wheat bran, 27% of broken maize, 23% of soybean meal, 16% of khesari bran, 1.5% of protein concentrate, 0.5% of vitamin-mineral pre-mix, 1% of DCP, and 1% of salt.

Sample collection and data recording

Blood samples were obtained from the kids to analyze the levels of T3 (triiodothyronine), T4 (thyroxine), and cortisol hormones. All blood samples were aseptically taken from the jugular vein using a vaccinator tube (Figure 1). The levels of T3 (triiodothyronine), T4 (thyroxine), and cortisol hormones were measured by using Biosystems-A15 Automated Biochemistry Analyser (Biosystems, Barcelona, Spain) according to manufacturer recommended commercial kit for veterinary use in blood samples collected from kids in different weaning schedules. The treatment groups were labeled as A, B, C, and D. The hormone analysis was conducted three days before the weaning schedule (-3) and three days after the weaning schedule (+3). The heart rate of the kid was measured using Polar-S810i Heart Rate Monitors (Polar, Kempele, Finland) (Figure 1) at three-time points: three days before weaning (-3), the day of weaning (0), and three days following weaning (+3) for various treatment groups. In addition to the mentioned factors, other parameters including birth weight, weaning weight, weight at 6 months, dry matter intake (DMI), daily growth rate at different developmental stages, incidence of diseases, and mortality rate among the kids were also recorded.

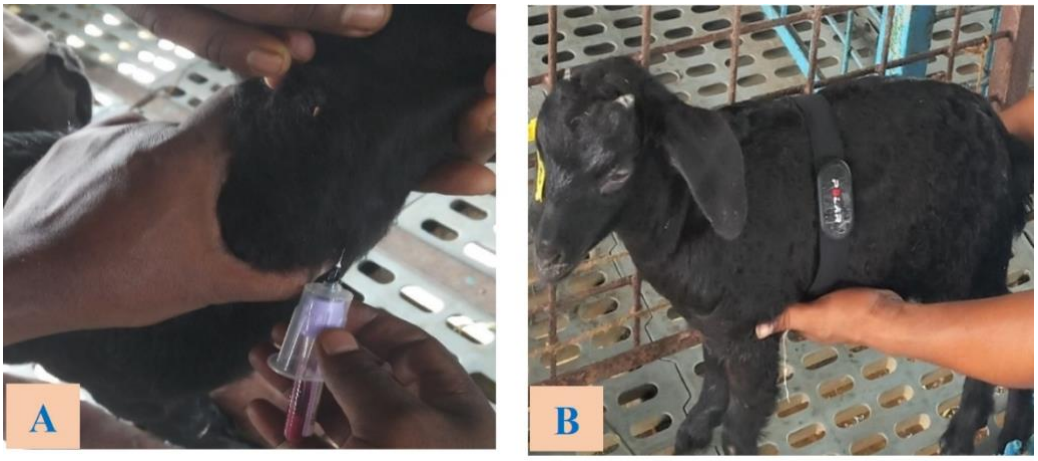

Figure 1. Pictures of taking blood and BPM from goats. A) Shows blood samples were collected from the jugular vein by using a vacuum blood collection tube and B) shows the number of heartbeats/minutes of the kids measured by using Polar-S810i heart rate monitors.

Statistics analysis

The data underwent analysis using the Generalized Linear Model (GLM) procedure in the Statistical Package for the Social Sciences (SPSS 2020). The analysis involved a factorial design with dimensions of 4x3 and 4x2, as well as an analysis of variance (ANOVA) conducted under a Completely Randomized Design (CRD). To ascertain the distinctions between means, Duncan's Least Significant Difference (LSD) test was employed.

RESULTS

Estimation of weaning stress

The T3, T4, and cortisol hormones were observed to assess the stress levels at different weaning ages in kids (Table 1). Although the concentration of T3 and T4 hormones didn't differ significantly according to groups, the serum concentration of T3 hormones decreased significantly ($p<0.05$) at +3 days after weaning compared to -3 days before weaning. The results suggested that the kids under A, B, and C groups experienced more stress from weaning compared to those in group D.

The heart rate of kids also exhibited a significant rise ($p<0.05$) as a result of the stress experienced throughout the weaning process (Table 2 and Table 3). The maximum beats per minute (BPM_max) and average beats per minute (BPM_av) in groups C and D exhibited their highest values on the initial sampling day (day 0) and subsequently decreased by three units. However, in the case of groups A and B, a significant increase ($p<0.01$) was detected, starting from day 0 of the sample period, with the highest value recorded on day +3.

Table 1. Changes in blood hormone levels in different treatment groups at different sampling dates

Treatments	Sampling day	T3, ng/ml	T4, ug/dl	Cortisol, ug/dl
A	-3	34.75±4.54	27.33±2.29	0.58±0.43
	+3	21.75±4.54	24.55±2.29	2.26±0.43
B	-3	37.34±4.98	28.76±2.50	0.67±0.47
	+3	26.20±4.98	23.80±2.29	1.63±0.43
C	-3	35.80±4.54	26.78±2.29	0.66±0.43
	+3	23.82±4.54	27.80±2.29	0.82±0.43
D	-3	26.63±4.54	23.80±2.29	0.28±0.43
	+3	31.33±4.54	27.90±2.29	0.31±0.43
Treatment (T)	A	28.25±3.21	25.94±1.62	1.42^{a}±0.31
	B	31.26±3.37	26.05±1.70	1.22^{b}±0.32
	C	29.81±3.21	27.29±1.62	0.67^{c}±0.31
	D	28.98±3.21	25.85±1.62	0.29^{c}±0.31
Day (d)	-3	33.47±2.33	26.58±1.17	0.79±0.22
	+3	25.78±2.27	26.01±1.14	1.21±0.22
Sig. level	T	NS	NS	*
	d	*	NS	*
	T x d	NS	NS	*

Data are mean±SE, T3 (triiodothyronine), T4 (thyroxine), and different superscripts in the same column differ significantly, *p<0.05.

Table 2. The average value of BPM of different weaning groups of BBG kids at different sampling days

Treatments	**BPM_max** (mean±SE).			**BPM_av** (mean±SE).		
	Sampling Day			Sampling Day		
	-3	0	+3	-3	0	+3
A	80.80±6.36	91.06±5.89	133.92±6.98	74.70±5.24	80.46±4.86	115.36±5.74
B	153.10±7.11	166.10±7.60	160.08±7.60	134.48±5.86	152.10±6.26	142.13±6.26
C	113.26±6.70	145.67±6.70	130.37±6.70	96.67±5.52	131.41±5.52	121.11±5.52
D	155.43±7.60	172.00±7.60	156.19±7.60	130.29±6.26	139.86±6.26	138.90±6.26

Data are mean±SE, BPM_max= highest no. of heartbeat/minute, BPM_Av= average no. of heartbeat/minute

Table 3. The overall effect of BPM value of different weaning groups of BBG kids on different weaning times and sampling days.

Parameters	**Groups (T)** (mean±SE)				**Sampling day** (mean±SE)			**Significance**		
	A	B	C	D	-3	0	+3	T	d	Txd
BPM_max	99.54^{c}±3.71	159.77^{a}±4.30	129.77^{b}±3.87	161.21^{a}±4.39	123.41^{a}±3.48	130.13^{a}±3.49	149.46^{a}±3.62	**	**	**
BPM av	88.23^{c}±3.10	142.86^{a}±3.54	116.40^{b}±3.19	136.35^{a}±3.62	107.82^{a}±2.87	113.91^{a}±2.88	133.44^{b}±2.99	**	**	**

BPM_max= highest no. of heartbeat/minute, BPM_Av= average no. of heartbeat/minute, different superscripts in the same row differ significantly, **p<0.01, T=treatment, and sampling day (d). Data are mean±SE.

Weaning age and post-weaning performance of BBG kids

Table 4 represents the post-weaning performances of different kid groups who were weaned at different ages. There was no significant difference (p>0.05) in the birth weight among the selected groups. However, there was a significant difference (p>0.05) in the average weaning weight of the kids across the various groups since they were weaned at different ages.

Health issues for different groups of kids were monitored throughout the study period. Pneumonia, coccidiosis, dermatitis, and lameness were the most prevalent diseases or health problems observed during the experiment (Table 5). Two kids from the 45-day weaned group and one from the 60-day weaned group died between weaning to six months of age, respectively, from coccidiosis, pneumonia, and dermatitis with weakness. The kid mortality rate was 12.5% for the 60-day and 25% for the 45-day weaned groups, and 0% for the 90-day and 75-day weaned groups, respectively.

Table 4. The post-weaning performances of various groups of kids.

Parameters	Treatment groups				S.E.M.	Level of Sig.
	A	B	C	D		
Birth weight, (kg)	1.15	1.10	1.03	1.07	0.044	NS
Weaning weight, (kg)	3.15^{b}	4.33^{ab}	4.88^{ab}	5.52^{a}	0.299	*
Six-month weight, (kg)	7.32^{b}	8.19^{ab}	8.84^{ab}	10.35^{a}	0.448	*
Total DMI, (g)	130.03	151.01	166.09	170.27	7.36	NS
Daily weight gain from weaning to 6 months, (g)	30.90^{b}	32.15^{b}	37.71^{b}	53.70^{a}	2.78	**

DMI, dry matter intake, and data are mean±SE. Different superscripts in the same row differ significantly, *p<0.05.

Table 5. The incidence of diseases among the kids across various treatment groups within the designated trial period.

Diseases/Health Problems	Treatment groups			
	A	B	C	D
Pneumonia, (no.)	1.0	1.0	0	0
Coccidiosis (no.)	2.0	2.0	1.0	1.0
Dermatitis, (no.)	0	1.0	0	0
Lameness, (no.)	1.0	1.0	0	0
Total (no. of kids)	4.0	5.0	1.0	1.0
Disease incidence (%)	50.00	62.50	12.50	12.50
Death (no.)	2.0	1.0	0	0
Kid mortality, (%)	25.00	12.50	0	0

DISCUSSION

The process of weaning is typically a challenging phase in the early life of a kid, generally accompanied by a reduction in the rate of weight increase, a complete cessation of growth, and occasionally, even a decline in body weight [8].

The study found a significant decrease ($p<0.05$) in thyroid hormone levels at +3 days following weaning. Thyroid hormone release decreases during stressful conditions [22, 30]. Cortisol concentration increased significantly ($p<0.05$) at +3 sampling days. This increment was 3 to 4-fold more from groups A and B. Heimbürge et al. [31], Gong et al. [32], and Bayazit et al. [33] reported that, in stressful conditions, cortisol concentration was also increased. However, in Saanen goats, significant changes were not observed in T3 and T4 hormones of the pre-and post-weaning periods [34]. Cortisol hormone levels may decrease with age [34, 35]. Hence, results suggested that kids in groups A and B were more stressed due to weaning than kids in the C and D groups. Right after birth, a goat kid's rumen is small and immature, and its digestive system is not yet entirely capable of processing complex plant materials. The maturation of the rumen is a gradual process influenced by the goat's diet [9]. As the kid consumes more solid food, especially fibrous plant material such as hay and grass, the rumen enlarges and develops a more extensive microbial population. These microbes break down cellulose and other complex carbohydrates in plants, aiding their digestion. The goat's rumen is generally well-developed and functioning efficiently around three months of age. At this stage, the goat primarily relies on its rumen for digestion and obtaining nutrients from plant-based diets [36].

Heart rate variability (HRV), which examines how the heart beats to show how the body reacts to stressors, is another method for detecting stress [37] and nowadays it is preferably used for stress assessment in animal husbandry. Measurement of HRV was done using a heart rate monitor Polar-S810i. [38], where heart rate, recorded as beats per minute (BPM), may regulate the workload during physical activity, exercise, or stress [39, 40]. As in humans, a linear relationship between BPM and maximum oxygen

uptake has been shown among animals. So, if BPM increases, then animals are in stress conditions. Results showed that group C and group D had less BPM than groups A and B indicating that goat kids weaned at 75 to 90 days were under less stress than goat kids weaned at 45 to 60 days, and this result supports the findings of Hampson and McGowan [38], Sporkmann *et al.* [39] and Ogata *et al.* [40]. BPM has been used in the literature as a physiological measure to evaluate stress and welfare in dogs [41, 42]. There needs to be more studies about BPM measurement and its relation to stress in goats. In addition, current research suggests that animals with more BPM have a stress condition similar to the other animal study mentioned above. The findings indicated that kids belonging to groups A and B experienced the highest levels of stress as a result of early maternal separation.

There was a significant difference in the average weaning weight of the kids across the various groups ($p>0.05$) as the kids in the various groups were weaned at different ages. Since a higher weaning weight helps a goat kid to attain the market and reproduction age faster, weaning weight is an important parameter for kids growing up in business enterprises. Typically, weaning weight depends on age, parity, litter size, milk production of the dam, and the sex of the kids, as well as the days the animals are weaned [10, 43]. This experiment found significant differences in weaning weights among the groups, with the highest value of 5.52kg for the 90-day weaned group and the lowest value of 3.15 kg for 45-day goat kids, which is comparable with Chakrabarti *et al.* [44], where authors showed an overall mean of 4.82±.20kg weaning weight of a BBG kid at three months of age is lower than what was found in this experiment. Solaiman *et al.* [45] found a 3-month weaning weight of 5.41kg and 4.97kg for male and female BBG kids, whereas Alam [46] found 5.70kg and 5.01 kg for male and female kids, which agreed with the finding of the present study. Higher weaning age, dam's age, and parity trigger the weaning weight to get high, while kids born from multiple births tend to attain lower weaning weight.

Typically, BBG goat attains sexual maturity at six months of age. To attain sexual maturity at six months, BBG goat has to meet a certain body weight, at least half of the mature weight. Furthermore, a farmer might market his goats as early as six months if they weigh around 10-12 kg. Several factors such as weaning age, weight, sex of the animals, and system of rearing determine the value of six months body weight of BBG. In the experiment, kids' weight differed significantly among the groups, where the highest weight of 10.55kg was observed when kids were weaned at 90 days, and a lower value of 7.32kg was found when kids were weaned at 45 days and might affect the profitability of the farm. The findings are comparable with other authors. According to Solaiman *et al.* [45], BBG attained 9.18kg and 8.02kg of six months weight for male and female goats, respectively, whereas Alam [46] showed a six-month weight of 8.65kg and 7.40kg for male and female BBG. When a goat kid possesses a high weaning weight, then it may carry a higher six-month weight. Weaning age greatly influences six months of body weight of BBG. Typically, 90 days or more is needed for the complete development of reticule-rumen in goat kids [46]. As a result, a goat kid weaned below 90 days cannot utilize roughages, possesses an underdeveloped rumen, and may not attain optimum body weight at six months.

Similar to six months' body weight, it has been found huge variation among the groups for daily weight gain from weaning to six months of age, where 90 days weaned group showed the highest daily gain of 53.70g per day and the lowest value of 30.90g found for 45 days weaned groups. These results show consistency with Vickery *et al.* [8] and Ibrahim *et al.* [47], who stated that average daily gain was significantly higher for kids weaned at 8 and 10 weeks than those weaned at 4 and 6 weeks of age (143g, 144g, 125g,

126g). In an early weaning system retarded growth rate is experienced as milk consumed by kids is lower than delayed weaned kids. Also, the early weaned kids need help to utilize other feedstuffs properly due to incomplete development of the rumen reticulum.

DMI of the animals mostly depends on the dam's age, body weight, rearing system, parity, and milk production. At an early age, a goat kid only relies on milk for survival, and then gradually develops the rumen reticulum [48]. In this experiment, the average DMI per day from weaning to six months of age tended to increase with increases in the weaning age of the kid, where 90 days weaned kids consumed a total of 170.27gm dry matter, and 45 days weaned kids consumed 130.03gm dry matter per day. However, the differences among the treatment groups were non-significant. Literature regarding average dry matter intake from weaning to six months of age is limited. An early-weaned goat kid not only consumes less milk than a late-weaned but also takes less other feedstuff due to incomplete rumen development [48, 49].

Early-weaned animals encountered more diseases compared to late-weaned animals [50, 51]. The result of the study also found in a similar vein that, the 45 days and 60 days-weaned groups encountered more health problems than the other two late-weaned groups of kid possibly due to their poor health and low immunity achieved from early weaning.

CONCLUSIONS

The growth and productivity of BBG kids could be negatively impacted if they are weaned too early specifically before 75 days of age. The study also suggested that the post-weaning performance of BBG kids is adversely affected by the age at which they were weaned. Kids who were weaned at 75 days to 90 days had fewer health and behavioral issues. In conclusion, the weaning age for BBG kids should not be less than 75 days. Further study is needed to minimize the weaning stress with proper management of BBG Kids.

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AUTHOR CONTRIBUTIONS

SA: Conceptualization, designing the experiment, laboratory test, data analysis, and interpretation, critical review, and funding acquisition. MAH and MHR: Laboratory test, data analysis, drafted and revised the manuscript. MMHP and MHR: Farm experiment, revising the draft, and made it up to the final stage. NJ: Data analysis and result drafting. All authors have read, reviewed, and approved the final manuscript.

CONFLICTS OF INTEREST

There is no conflict of interest among the authors.

REFERENCES

[1] DLS, Department of Livestock Service, Livestock Economy at a glance 2022-2023. Ministry of Fisheries and Livestock, Bangladesh. http://www.dls.gov.bd/site/page/22b1143b-9323-44f8-bfd8-647087828c9b/Livestock-Economy (accessed on 17 April, 2024)

[2] Rahman MH, Akther S, et al. Incidence of diseases in goats in Bangladesh. Bangladesh Veterinarian. 2020; 37(1-2): 14-20.

[3] Akhtar A, Hoque MA, et al. A study on morphological characterization of Black Bengal goat at three Villages under Bhaluka upazila in Mymensingh district of Bangladesh. Int J Livest Prod. 2021; 12(2): 86-97.

[4] Ahmed EM, Amin MR, et al. Phenotypic characterization and production potentials of exotic goat breeds and their crosses in Rajshahi metropolitan area of Bangladesh. Bang J Anim Sci. 2020; 49 (2): 100-107.

[5] Rakib MR, Ahmed S, et al. Morphometric features and performances of Black Bengal goat in Bangladesh. Trop Anim Health Prod. 2022; 54(6): 341.

[6] Hossain ME. Performance of Black Bengal goat: a 50-year review. Trop Anim Health Prod. 2021; 53(1): 71.

[7] Moni MI, Samad MA. Evaluation of productive and reproductive performances of Black Bengal goats in Rajshahi government goat development farm in Bangladesh. J Vet Med OH Res. 2019; 1(2): 201-210

[8] Vickery HM, Neal RA, et al. Gradually weaning goat kids may improve weight gains while reducing weaning stress and increasing creep feed intakes. Front Vet Sci. 2023; 10: 1200849.

[9] Abdelsattar MM, Zhao W, et al. Physical, metabolic, and microbial rumen development in goat kids: A review on the challenges and strategies of early weaning. Animals. 2023; 13(15): 2420.

[10] Datt M, Bhateshwar V, et al. Importance of body weight, age and body condition in weaning of goat kids: a review. J Livest Sci. 2023; 14(1): 71-77.

[11] Magistrelli D, Aufy AA, et al. Analysis of weaning-induced stress in Saanen goat kids. J Anim Physiol Anim Nutr. 2013; 97(4): 732-739.

[12] Hoon JH, Olivier WJ, et al. The effect of different weaning practices on post-weaning growth of angora kids and reproduction of angora ewes. In: Book of Abstracts for the 10th World Conference on Animal Production. Wageningen Academic: Netherlands, Brill, 2023, pp 190.

[13] Mann KS, Chandrahas, et al. Weaning stress management in Beetal kids under stall-fed conditions. J Appl Anim Res. 2015; 43(2): 202-207.

[14] Husain SS, Horst P and Islam ABMM. Effect of different factors on pre-weaning survivability of Black Bengal kids. Small Rumin Res. 1995; 18(1): 1-5

[15] Veissier I, Boissy A. Stress and welfare: Two complementary concepts that are intrinsically related to the animal's point of view. Physiology & behavior. 2007; 92(3): 429-433.

[16] Rushen J. Some issues in the interpretation of behavioural responses to stress. InThe biology of animal stress: basic principles and implications for animal welfare. CABI Publishing: Wallingford, UK, 2000, pp 23-42.

[17] Ataşoglu C, Yurtman İY, et al. Effect of weaning on behavior and serum parameters in dairy goat kids. Anim Sci J. 2008; 79: 435–442.

[18] Möstl E, Palme R. Hormones as indicators of stress. Domest Anim Endocrinol. 2002; 23(1-2): 67-74.

[19] Endris M, Feki E. Review on effect of stress on animal productivity and response of animal to stressors. J Anim Vet Adv. 2021; 20(1): 1-4.

[20] Vijayan MM, Aluru N, et al. Stress response and the role of cortisol. Fish diseases and disorders. 2010; 2: 182-201.

[21] Todini L, Malfatti A, et al. Plasma total T3 and T4 concentrations in goats at different physiological stages, as affected by the energy intake. Small Rumin Res. 2007; 68: 285–290.

[22] Behringer V, Deimel C, et al. Applications for non-invasive thyroid hormone measurements in mammalian ecology, growth, and maintenance. Hormones and Behavior. 2018; 105: 66-85.

[23] Pereira AM, Baccari F, et al. Effect of thermal stress on physiological parameters, feed intake and plasma thyroid hormones concentration in Alentejana, Mertolenga, Frisian and Limousine cattle breeds. Int J Biometeorol. 2008; 52: 199-208.

[24] Dhabhar FS. Enhancing versus suppressive effects of stress on immune function: implications for immunoprotection and immunopathology. Neuroimmunomodulation. 2009; 16(5): 300-317.

[25] Segerstrom SC, Miller GE. Psychological stress and the human immune system: a meta-analytic study of 30 years of inquiry. Psychol Bull. 2004; 104: 601-630.

[26] Padgett DA, Glaser R. How stress influences the immune response. Trends Immunol. 2003; 24: 444–448.

[27] Eckert E, Brown HE, et al. Weaning age affects growth, feed intake, gastrointestinal development, and behavior in Holstein calves fed an elevated plane of nutrition during the preweaning stage. J Dairy Sci. 2015; 98(9): 6315-6326.
[28] Weary DM, Jasper J, et al. Understanding weaning distress. Appl Anim Behav Sci. 2008; 110(1-2): 24-41.
[29] Bushby EV, Friel M, et al. Factors influencing individual variation in farm animal cognition and how to account for these statistically. Front Vet Sci. 2018; 5: 193.
[30] Helmreich DL, Tylee D. Thyroid hormone regulation by stress and behavioral differences in adult male rats. Hormones and Behavior. 2011; 60(3): 284-291.
[31] Heimbürge S, Kanitz E, Otten W. The use of hair cortisol for the assessment of stress in animals. Gen Comp Endocrinol. 2019; 270: 10-17.
[32] Gong S, Miao YL, et al. Dynamics and correlation of serum cortisol and corticosterone under different physiological or stressful conditions in mice. PloS one. 2015; 10(2): e0117503.
[33] Bayazit V. Evaluation of cortisol and stress in captive animals. Aust J Basic Appl Sci. 2009; 3(2): 1022-1031.
[34] TÖLÜ C, Göktürk S, et al. Effects of housing environment on social isolation response, weaning stress, and immune reaction in goat kids. Turk J Vet Anim Sci. 2017; 41(5): 635-642.
[35] Koser Eliçin M. Akkeçilerde tiroid hormonlarının değişimi. PhD, Ankara University, Ankara, Turkey, 2008 (in Turkish).
[36] Souza CS, Vieites FM, et al. Importance of intestinal health in broilers. Res Soc Dev. 2020; 9(3), 1-18.
[37] Jay Brewer (2022). How does my heart rate show if I am stressed? (https://www.nuffieldhealth.com/article/how-does-my-heart-rate-show-if-im-stressed#about)
[38] Sporkmann K, Georg H, et al. Heart rate variability of goat kids to evaluate stress in different weaning situations. Landtechnik. 2012; 67(6): 417-420.
[39] Hampson BA, McGowan CM. Physiological responses of the Australian cattle dog to mustering exercise. Equine Comp Exerc Physiol. 2007; 4(01): 37–41.
[40] Hopster H, Blokhuis HJ. Validation of a heart-rate monitor for measuring a stress response in dairy cows. Can J Anim Sci. 1994; 74(3): 465-474.
[41] Ogata N, Kikusui T, et al. Objective measurement of fear-associated learning in dogs. J Appl Physiol. 2006; 1(2): 55–61.
[42] Palestrini C, Previde EP, et al. Heart rate and behavioral responses of dogs in the Ainsworth's strange situation: a pilot study. Appl Anim Behav. 2005; 94(1–2): 75–88.
[43] El-Raghi AA, Hashem NM. Maternal, postnatal, and management-related factors involved in daily weight gain and survivability of suckling Zaraibi goat kids in Egypt. Animals. 2022; 12(20): 2785.
[44] Chakrabarti A, Godara RS, et al. Pre-weaning growth performance of Black Bengal goat kids in an organized farm in Tripura. J Pharm Innov. 2022; 11: 2383-2385.
[45] Solaiman, M, Apu A, et al. Impact of the community-based breeding program on breeding buck availability, growth and reproductive performance of Black Ben-gal goat. Bangl J Anim Sci. 2020; 49(1): 13-21
[46] Alam, M.M.M.M. Growth performance of black Bengal goat at Gaibandha district in Bangladesh. M.S. thesis. Faculty of Animal Science& Veterinary Medicine, Sher-e-Bangla Agricultural University, Dhaka, 2019.
[47] Ibrahim NS, Noor NN, et al. Evaluation of growth parameters and body condition score on weaning stages of Saanen goats. J Adv Vet Anim Res. 2022; 9(3): 527.
[48] Perdomo C. Late weaning improves growth performance and rumen development in Alpine goats. PhD Thesis, Faculty of Veterinary Medicine, University of Montreal, Canada.
[49] Prasad CK, Abraham J, et al. Growth performance and rumen development in Malabari kids reared under different production systems. Trop Anim Health Prod. 2019; 51(1): 119-129.
[50] Arshad MA, Hassan FU, et al. Gut microbiome colonization and development in neonatal ruminants: Strategies, prospects, and opportunities. Animal Nutrition. 2021; 7(3): 883-895.
[51] Amjad M, Hameed N, et al. Effect of weaning method on body weight, testicular growth, sexual behavior, age of puberty, and testosterone concentration of Beetal bucks. Anim Sci J. 2021; 92(1): e13520.