*J. Indian Soc. Coastal Agric. Res. 41(2): 100-107 (2023) https://doi.org/10.54894/JISCAR.41.2.2023.141794*

# Evaluating the Growth Performance of Black Bengal Goats in Coastal Sundarban of West Bengal

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Received: 01.09.2023 Accepted: 15.12.2023

**To evaluate the growth performance of 3495 Black Bengal kids from Jatirampur village of Sundarban area of South 24 Parganas, West Bengal, the data were collected for a period of 15 years (2008-2022) to ascertain the effect of various environmental factors on growth traits and their genetic control over growth performance. Least-squares analysis of variance was applied to determine the effect of non-genetic factors on different growth traits of kids. The heritability of growth traits was estimated by the paternal half-sib method and animal model. The overall least-squares means for weights at birth, 3-, 6-, 9- and 12- months of age were 1.19 ± 0.004, 5.44 ± 0.01, 7.74 ± 0.01, 10.68 ± 0.01 and 13.37 ± 0.01 kg, respectively. The study revealed the periods of birth had a significant (P<0.01) effect on all the growth traits under the study. The kids born in different seasons showed significant variation in body weights recorded in various intervals except in 3rd month. Similarly, a significant effect was shown by the sex of kids on the 3-month body weight of kids. Parity of dam and type of birth showed significant (P<0.05) effects on all traits except the birth weight of kids. Kids born from does of third or later parities had significantly (P<0.05) higher body weights than kids born from does of earlier parities. Single-born kids exhibited significantly (P<0.01) higher body weights at all ages except weight at birth than kids born as twins or triplets. The study also revealed that estimates of heritabilities for all growth traits were low to medium in magnitude, ranging from 0.04 to 0.48, indicating the scope of slow to moderate genetic progress of these traits through selection under the prevalent managemental condition at the region.**

(***Key words:*** *Body weight, Coastal India, Goat, Heritability, Production performance, Sundarban*)

Goat offers livelihood and nutritional security to the marginal, small and landless farmers of India. Black Bengal (*Capra hircus bengalensis*) goat, a valuable goat germplasm of India, is widely distributed in different parts of West Bengal, including the coastal part of the state. This breed plays an important role in supporting the livelihood of the goat farmers/rearers in these regions. Most of the farmers of these regions maintain small flocks of 3-5 goats under a low or zero input system of rearing. This breed is known for its quality meat (chevon) and leather all over the world. Other important attributes like early sexual maturity, high fecundity, low kidding interval, good adaptability to adverse climates and steady return attract farmers towards rearing this breed. This animal can attain puberty by 6 to 9 months of age and have a high fecundity rate (single 27-33%, twinning 50-55%, triplet 10-15%, quadruplet 5-7%) along with shorter kidding interval of 179 days (Hassan *et al.,* 2007). Besides, they produce delicious meat with low intramuscular fat and fine-quality skin (Islam *et al.,* 1991). Due to the high demand for meat in Eastern India, goats are slaughtered at an earlier age in the farmers' flock for better consumer appeal, which leads to under-evaluation of this breed at the village level.

Early growth traits are important factors influencing the profitability of any meat-producing enterprise. Body weights of kids at different ages are the reflection of the adaptability and economic viability of the animal and hence may be used as criteria for the selection among breeds and the individual within breeds (Singh *et al.,* 2006). Detailed evaluation of the growth performance of goats is the utmost prerequisite for the genetic

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improvement program in any goat breeding enterprise. So, proper evaluation of the growth performance of Black Bengal will help to design the future strategy for increasing the productivity of this breed, which in turn may provide self-sustainability among these goat keepers. Several non-genetic/environmental factors significantly affected the growth performance of animals, which directly obscured the genetic potential of animals. So, to obtain reliable estimates of important economic traits including growth traits and to increase the accuracy of the selection of breeding animals, adjustment of data for non-genetic factors is necessary. Various studies showed that different environmental factors affect the animal growth (Jasmine *et al.,* 2022; Mandal *et. al.,* 2018). As the detailed evaluation of the performance of this breed at farmers' flock of the coastal zone of Sundarban has not been carried out so far, therefore the present study was undertaken to determine the effect of various environmental factors on growth traits and to study their genetic control over the growth performance.

## MATERIALS AND METHODS

### Study location and animals

The present study was conducted to evaluate the growth performance of Black Bengal goats, reared under semi-intensive feeding management at the coastal saline zone (Jatirampur village of Gosaba block in Sundarban) of South 24 Parganas, West Bengal, under the "All-India Coordinated Research Project on Goat Improvement, Black Bengal, Kolkata Field Unit". The study area is located in the Rangabelia gram panchayat of Gosaba Block of Sundarban at 22°09′55″ N latitude and 88°48′28″ E longitude with an elevation of 6 m above mean sea level. The annual temperature ranges between 21-32ºC and relative humidity ranges from 70 to 80%. The region is frequently affected by tropical cyclones due to its proximity to the sea, the Bay of Bengal.

The goats were kept mainly under the kutcha house (Fig. 1) and reared under an extensive system with 6-8 hours of grazing by tethering along the roadside or in harvested paddy fields (Fig. 2). Farmers used tethering rope in case of tethered grazing. Generally, grazing was allowed from 9.00 A.M to 3.00 P.M. (6 hours) continuously during the winter season and from 7.00 A.M to 12.00 noon & from 3.00 P.M to 5.00 P.M (7 hours) on an intermittent basis during summer. Certain percentages of goat owners allowed both grazing and tethering (tethering in the morning and grazing in the afternoon). In addition, tree leaves, bushes, grasses and seasonal fodders were also offered to the animals after returning from the grazing field. Supplementation of concentrates to goats as practiced by farmers is very less. Few numbers of goat owners could supply a balanced concentrate mixture, and a very small percentage of farmers provided single concentrate (e.g. broken wheat) or a combination of two or three (e.g., mixture of broken wheat, rice bran, wheat bran, rice gruel, dal chuni, broken rice & oil cakes). Few farmers used to practice feeding the mineral mixture through rice gruel. During the rainy season, when the scope of grazing becomes limited due to rain, the maximum number of animals is supplemented with grasses and tree leaves. Grasses and tree leaves are the most commonly used items as

***Fig. 1.*** *Kutcha house for goat at Sundarban village*

***Fig. 2.*** *Grazing by tethering of animals at village level*

feed supplements. Kids suckled their mother for about 3 months. In most cases, kids are allowed to graze with their mother. Milk, rice gruel, barley and miscellaneous items were the types of feed supplements used in the case of suckling kids. Milk used as supplements is taken from cattle or buffalo as milk production of Bengal doe is very less and often it is found to be critically less in the case of triplet or quadruplet born kids. Supplementary feeding of suckling and weaned kids is also common. Weaned kids are provided with supplementary feed like grass, concentrate and miscellaneous materials. However, the practice did not vary much from season to season. Occasionally, pregnant and lactating does were offered some quantity of concentrate mixtures.

Natural mating was practiced with the selected bucks throughout the season. Does were first exposed to bucks at the 8$^{th}$ month of age. Generally, the does were bred 12-15 hours after the onset of heat. Normally one breeding buck was allowed to mate with 25-30 does, and the breeding buck was not used for more than 3 years old in a particular village. Most of the does generally showed estrus after 2 months post-kidding. At kidding, both kids and does were weighed and the kidding date, sex and birth type of each kid were recorded. Generally, kids were allowed to suckle their dam up to weaning *i.e.,* 60 days of age. Kids were weighed by hanging digital spring balance (Fig. 3) at monthly intervals from birth to 12 months of age. Deworming of animals was done mainly during the rainy season. Animals were vaccinated (Fig. 4) against peste des petits ruminants (PPR), goat pox, and enterotoxaemia (HS).

**Data and traits included**

Growth performance data of 3495 Black Bengal kids, descended from 489 does and 39 bucks, were collected for a duration of 15 years (2008-2022) and used for this study. The body weights at different stages (*i.e.,* at birth, 3, 6, 9 and 12 months) were recorded. The data were classified according to year of birth/kidding, season of birth, parity of dam, sex of kid and birth status of kid.

**Statistical analyses**

To evaluate the effect of different environmental (non-genetic) effects on the growth traits of animals, data were analyzed using a mixed model least-squares analysis for fitting constants (Harvey, 1990) including all main effects. The following model was used:

$$Y_{ijklmn} = \mu + Y_i + S_j + A_k + E_l + T_m + e_{ijklmn} \quad \ldots 1$$

where, $Y_{ijklmn}$ is the record for the $n^{th}$ lamb, $Y_i$ is the effect of the $i^{th}$ year of birth, $S_j$ is the effect of the $j^{th}$ season of birth, $A_k$ is the effect of the $k^{th}$ parity of dam, $E_l$ is the effect of the $l^{th}$ sex of kid, $T_m$ is the effect of the $m^{th}$ birth status/type of kid born, $e_{ijklmn}$ is the residual error element. The comparison of different sub-groups means was made by Duncan's multiple range test (DMRT) as described by Kramer (1957).

**Estimation of heritabilities of traits**

The heritability of growth traits was estimated by both the paternal half-sib method and the simple animal model.

***Fig. 3.*** *Weighing of animals in the coastal village*

***Fig. 4.*** *Vaccination of goats in the study area*

**Estimates by paternal half-sib method**

The following model was used:

$$Y_{ij} = \mu + S_i + e_{ij} \quad \ldots 2$$

where, $Y_{ij}$ = Observation of $j^{th}$ progeny of $i^{th}$ sire, $\mu$ = Population mean, $S_i$= Effect of $i^{th}$ sire, and $e_{ij}$ = Random error ~ NID (0, $\sigma_2 e$)

Sires having three or more progenies were considered for the study for heritability estimation of the trait.

**Estimates by animal model**

The heritability of different growth traits was estimated by a simple animal model. Only significant fixed effects obtained from least-squares analysis for each growth trait were included in the final model used for genetic parameter estimation of growth traits by animal model. The components of variance and heritability were estimated by Restricted Maximum Likelihood (REML) fitting the single-trait animal model (Meyer, 2007). The following simple animal model was used:

$$Y = Xb + Za + e \quad \ldots 3$$

where, Y is the vector of observations for the dependent variable (growth traits); X is the incidence matrix of fixed effects for the dependent variable and b is the corresponding vector of fixed effects; Z is the incidence matrix of the direct additive genetic effects; a is the vector of direct additive genetic effects associated with the Z incidence matrix and e is the vector of residual random effects associated with the observations.

## RESULTS AND DISCUSSION

**Environmental factors affecting growth traits**

The number of individuals available at one year of age was 47% lower than the number of kids at birth due to mortality, culling and sale aof animals. The average weights at birth, 3-, 6-, 9- and 12- months of age were 1.19 ± 0.004, 5.44 ± 0.009, 7.74 ± 0.01, 10.68 ± 0.01 and 13.37 ± 0.01 kg, respectively (Table 1). Similar body weights of kids at different stages as reported in this study were also well-congruent with the observation of Alam *et al.* (2021), Asad *et al.* (2020) and Kumar *et al.* (2021) in Black Bengal goats. Different environmental factors significantly (P<0.05) affected most of the growth traits of kids. Period of birth had a significant (P<0.01) effect on all the growth traits under study. Significant effects of year of birth on the body weights of kids were also reported by Jasmine *et al.* (2022) and Mandal *et. al.* (2018) for various breeds of goat. Differences in body weights of kids born in different years may be attributed to differences in management and environmental conditions such as ambient temperature, humidity, rainfall, etc. Significant variations for all body weights except weight at 3rd month were observed among kids born in different seasons. Kids born in the summer season had a higher weight at birth and subsequent body weights at different phases of growth than kids born in the rainy and winter seasons. Our finding was corroborated by the reports of Asad *et al.* (2020), Das *et al.* (2018) and Jasmine *et al.* (2022) in different breeds of goats. The lower body weights at birth and subsequent ages of the kids, born in rainy/winter in this study may be an effect of the ambient temperature since gestation period of the does would occur during the hot and humid period of the year. Parity of dam showed a significant (P<0.05) effect on all traits except on the birth weight of kids. Kids born from does of later parities had significantly (P<0.05) higher body weights than kids born from does of earlier parities. A similar significant effect of parity of the dam on different body weights of kids was observed by Bhusan and Dass (2015) in Jakhrana goats and Singh *et al.* (2013) in Jamunapari goats. However, Asad *et al.* (2020) and Jasmine *et al.* (2022) observed the significant effect of parity on all body weight traits except weight at 9- and 12 months of age in Black Bengal goats.

The sex of kids had a significant effect only on the 3-month body weight of Black Bengal kids in the current study. Similarly, the body weight differences between sexes at 3 months of age were also observed in other studies (Alam *et al.,* 2021; Asad *et al.,* 2020; Jasmine *et al.* 2022) for various goat breeds. Chakrabarti *et al.* (2022) also reported a non-significant effect of sex on the birth weight of this breed, as observed in our study. In our study, single-born kids exhibited significantly (P<0.01) higher body weights at all ages except weight at birth than kids born as twins or triplets. The significant effects of type of birth on the body weights of kids, as observed in this study, were also in agreement with the findings of Alam *et al.* (2021), Asad *et al.* (2020), Das *et al.* (2018), and Jasmine *et al.* (2022). In our study, the

***Table 1.*** *Least-squares means along with standard errors of different growth traits of Black Bengal goats in farmers' flock*

| Effects | Body weights (kg) | | | | |
|---|---|---|---|---|---|
| | Birth | 3-month | 6-month | 9-month | 12-month |
| Overall mean | 1.19±0.004 | 5.44±0.01 | 7.74±0.01 | 10.68±0.01 | 13.37±0.01 |
| Periods of birth | ** | ** | ** | ** | ** |
| POB 1 | 1.22±0.01$^{a}$ | 5.47±0.02$^{a}$ | 8.02±0.03$^{a}$ | 10.95±0.03$^{b}$ | 13.57±0.03$^{ab}$ |
| POB 2 | 1.18±0.01$^{b}$ | 5.43±0.01$^{bc}$ | 8.06±0.02$^{a}$ | 11.00±0.02$^{ab}$ | 13.58±0.02$^{ab}$ |
| POB 3 | 1.19±0.01$^{b}$ | 5.44±0.01$^{ab}$ | 8.10±0.02$^{a}$ | 11.03±0.02$^{a}$ | 13.62±0.02$^{a}$ |
| POB 4 | 1.15±0.01$^{c}$ | 5.40±0.01$^{c}$ | 7.61±0.02$^{b}$ | 10.44±0.02$^{c}$ | 12.98±0.02$^{d}$ |
| POB 5 | 1.20±0.01$^{ab}$ | 5.46±0.02$^{ab}$ | 6.91±0.03$^{c}$ | 9.96±0.03$^{d}$ | 13.10±0.03$^{c}$ |
| Seasons of birth | * | NS | ** | ** | ** |
| Summer | 1.20±0.01$^{a}$ | 5.43±0.01 | 7.79±0.02$^{a}$ | 10.73±0.02$^{a}$ | 13.42±0.02$^{a}$ |
| Rainy | 1.19±0.01$^{ab}$ | 5.47±0.02 | 7.70±0.02$^{b}$ | 10.62±0.02$^{b}$ | 13.32±0.03$^{b}$ |
| Winter | 1.18±0.01$^{b}$ | 5.43±0.01 | 7.73±0.02$^{b}$ | 10.67±0.02$^{b}$ | 13.36±0.02$^{b}$ |
| Type of birth | NS | ** | ** | ** | ** |
| Single | 1.19±0.01 | 5.61±0.02$^{a}$ | 7.78±0.02$^{a}$ | 10.73±0.02$^{a}$ | 13.43±0.03$^{a}$ |
| Twinning | 1.19±0.005 | 5.38±0.01$^{b}$ | 7.77±0.02$^{a}$ | 10.67±0.02$^{b}$ | 13.36±0.02$^{b}$ |
| Triplet | 1.18±0.01 | 5.33±0.02$^{c}$ | 7.67±0.02$^{b}$ | 10.63±0.02$^{b}$ | 13.32±0.02$^{b}$ |
| Sex of kid | NS | ** | NS | NS | NS |
| Male | 1.19±0.005 | 5.48±0.01$^{a}$ | 7.72±0.02 | 10.67±0.02 | 13.38±0.02 |
| Female | 1.18±0.01 | 5.40±0.01$^{b}$ | 7.76±0.02 | 10.68±0.02 | 13.35±0.02 |
| Parity of doe | NS | ** | ** | ** | * |
| 1 | 1.20±0.01 | 5.34±0.02$^{e}$ | 7.70±0.03$^{abcd}$ | 10.63±0.03$^{bc}$ | 13.33±0.03$^{b}$ |
| 2 | 1.18±0.01 | 5.39±0.02$^{d}$ | 7.65±0.02$^{d}$ | 10.65±0.02$^{abc}$ | 13.36±0.02$^{ab}$ |
| 3 | 1.18±0.01 | 5.39±0.02$^{cd}$ | 7.82±0.03$^{a}$ | 10.75±0.03$^{a}$ | 13.46±0.03$^{a}$ |
| 4 | 1.19±0.01 | 5.45±0.02$^{a}$ | 7.71±0.03$^{abcd}$ | 10.66±0.03$^{abc}$ | 13.38±0.03 |
| 5 | 1.18±0.01 | 5.44±0.02$^{ab}$ | 7.76±0.03$^{abc}$ | 10.72±0.03$^{a}$ | 13.33±0.03$^{b}$ |
| 6 | 1.17±0.01 | 5.45±0.02$^{a}$ | 7.72±0.03$^{abcd}$ | 10.66±0.04$^{abc}$ | 13.30±0.04$^{b}$ |
| 7 | 1.18±0.01 | 5.42±0.03$^{abc}$ | 7.74±0.04$^{abc}$ | 10.69±0.04$^{ab}$ | 13.37±0.04$^{b}$ |
| 8 | 1.21±0.01 | 5.48±0.03$^{a}$ | 7.79±0.04$^{ab}$ | 10.68±0.04$^{ab}$ | 13.33±0.04$^{b}$ |
| 9 | 1.17±0.01 | 5.43±0.03$^{abc}$ | 7.67±0.05$^{cd}$ | 10.55±0.05$^{c}$ | 13.34±0.05$^{b}$ |
| 10 | 1.21±0.02 | 5.50±0.04$^{a}$ | 7.70±0.05$^{bcd}$ | 10.67±0.05$^{abc}$ | 13.38±0.05$^{ab}$ |
| 11 | 1.20±0.02 | 5.51±0.04$^{a}$ | 7.82±0.06$^{a}$ | 10.78±0.06$^{a}$ | 13.43±0.06$^{a}$ |
| 12 or more | 1.19±0.02 | 5.49±0.04$^{a}$ | 7.79±0.05$^{abc}$ | 10.68±0.05$^{ab}$ | 13.41±0.05$^{a}$ |

Means with different superscripts between the rows in a column differed significantly
NS, Not significant (P>0.05); *, Significant (P<0.05); **, Highly Significant ( P<0.01)

smaller body weights of twin/triplet kids as compared to single-born kids may be due to the sharing of dams' uterine capacity by two or more fetuses, which restricts the fetuses from obtaining the optimum space for their growth. In addition, during the suckling period, the growth of two kids is limited by the amount of mother's milk which leads to lower body weights in twins compared to singles.

**Heritability estimates of growth traits**

The heritability estimates of different growth traits of Black Bengal goats are presented in Table 2. Using paternal half-sib method, the heritability estimates of weights at birth, 3-, 6-, 9-, and 12 months of age were 0.05 ± 0.02, 0.03 ± 0.02, 0.29 ± 0.08, 0.26 ± 0.08 and 0.48 ± 0.13, respectively, whereas, the corresponding

***Table 2.*** *Least-squares means along with standard errors of different growth traits of Black Bengal goats in farmers' flock*

| Traits | Heritability | |
|---|---|---|
| | Paternal half-sib | Animal model |
| Birth weight | 0.05 ±0.02 | 0.05±0.02 |
| 3-month weight | 0.03±0.02 | 0.03±0.02 |
| 6-month weight | 0.29±0.08 | 0.15±0.04 |
| 9-month weight | 0.26±0.08 | 0.43±0.07 |
| 12-month weight | 0.48±0.13 | 0.19±0.07 |

estimates under animal model were 0.05 ± 0.02, 0.03 ± 0.02, 0.15 ± 0.04, 0.43 ± 0.07 and 0.19 ± 0.07, respectively. The lower estimates of heritability of birth weight, as observed in both the analytical approaches, were well in agreement with the findings of Bangar *et al.* (2020) in Jakhrana goats and Gholizadeh *et al.* (2010) in Raeini goats. Similar heritability estimate for 3-month body weight was reported by Ekambaram *et al.* (2010) for Mahabubnagar goats (0.06). However, higher heritability for weights at birth and 3 months of age was reported by Baneh *et al.* (2012) in Naeini goat and Gul *et al.* (2023) in Kilis goat. Further, Akhtar *et al.* (2021) and Mia *et al.* (2013) also observed higher heritabilities for these traits in Black Bengal goats. In the present study, heritability estimate for weight at 6 months of age was in accordance with the results obtained by Boujenane and Hazzab (2008) in Draa (0.15) and Moghbeli *et al.* (2013) in Raini Cashmere goat (0.15). However, higher (Bangar *et al.,* 2020) and lower (Ekambaram *et al.,* 2010) estimates of heritability for this trait have been reported in various goat breeds. The heritability estimates for body weights of kids at 9- and 12- months of age demonstrated in the present study are within the range of those observed in the other goat breeds (Moghbeli *et al.,* 2013; Mohammadi *et al.,* 2012). As compared to our present findings, Bangar *et al.* (2020) and Gowane *et al.* (2011) observed lower heritabilities for these traits. The low heritability estimates of birth weight and 3-months weight may be attributed to the high maternal influence associated with kid performance at the early stage of growth. High maternal influence has a tendency to increase the component of environmental variance to the kid, thereby lowering heritability estimates. The increasing heritability of kid's body weight at the later stages of the developmental process in our study indicates that environmental factors, in relation to additive genetic factors, had more influence on early kid trait (birth weight) than on weights achieved later in the developmental stages. The moderate to high estimates of direct heritabilities for weights at 6, 9 and 12 months of age from the present study indicated greater genetic variability which may be exploited to a greater extent for selecting superior germplasm to bring genetic improvement in Black Bengal goats at farmers' flock.

The present study revealed that different environmental factors significantly affected the most of growth traits of Black Bengal goats in the coastal region. Low to moderate estimates of heritabilities of all body weight traits at different ages in this breed indicate some genetic progress is possible for these traits under the prevalent management system in the coastal area of West Bengal.

## CONFLICTS OF INTEREST

The authors don't have any conflict of interest for this article.

## ACKNOWLEDGEMENTS

Authors are thankful to the Hon'ble Vice Chancellor, West Bengal University of Animal & Fishery Sciences (WBUAFS), Belgachia, Kolkata, West Bengal and Director, ICAR-CIRG, Makhdoom, Mathura, Uttar Pradesh for extending the financial support to carry out this work. The help rendered by the Project Coordinator, AICRP on Goat Improvement, ICAR-CIRG, Makhdoom, Mathura, UP and Director of Research, Extension and Farm, WBUAFS, Kolkata to conduct the study in this field unit is also gratefully acknowledged. We also extend our thanks to the Head, ICAR-NDRI, Eastern Regional Station, Kalyani, West Bengal for the help in analysing and preparing the manuscript.

## REFERENCES


Alam, M.M., Alam, M.J., Kabir, M.E., Jalil, M.A., Chandra, M. and Begum, D.M. (2021). Growth performance of Black Bengal goats at rural areas of Gaibandha district in Bangladesh. *Bangladesh Journal of Veterinary and Animal Sciences* **9**(1): 10-16.

Akhtar, A., Hoque, M.A., Bhuiyan, A.K.F.H., Amin, M.R. and Habib, M.A. (2021). Phenotypic performance and response to selection for body weight gains of Black Bengal goat in a community breeding program. *African Journal of Agricultural Research* **17**(7): 1058-1067.

Asad, L.Y., Tabreze, M.M.S., Amy, B.F. and Dadok, F. (2020). The growth performance of Black Bengal goat in village condition of Bangladesh. *Journal of Agriculture, Food and Environment* **1**(3): 39-46. https://doi.org/10.47440/JAFE.2020.1306.

Baneh, H., Najafi, M. and Rahimi, G. (2012). Genetic parameter estimates for early growth traits in Naeini goat. *Animal Production Science* **52**: 1046-1051.

Bangar, Y.C., Magotra, A. and Yadav, A.S. (2020). Variance components and genetic parameter estimates for pre-weaning and post-weaning growth traits in Jakhrana goat. *Small Ruminant Research* **193**: 106278. https://doi.org/10.1016/j.smallrumres.2020.106278.

Bhusan, S. and Dass, G. (2015). Influence of non-genetic factors on body weights of Jakhrana kids. *Indian Journal of Animal Sciences* **85**: 60-63.

Boujenane, I. and Hazzab, A. (2008). Genetic parameters for direct and maternal effects on body weights of Draa goats. *Small Ruminant Research* **80**: 16-21.

Chakrabarti, A., Godara, R.S. and Singh, V. (2022). Pre-weaning growth performance of Black Bengal goat kids in an organized farm in Tripura. *The Pharma Innovation Journal* **11**: 2383-2385.

Das, B.C., Bera, S., Pandit, S., Panda, R. and Roy, M. (2018). Studies on growth parameters of Black Bengal goats in coastal Sundarban of West Bengal. *International Journal of Fauna and Biological Studies* **5**: 1-4.

Ekambaram, B., Gupta, R.B., Prakash, G.M., Sudhaker, K. and Reddy, V.R. (2010). A study on the performance of Mahabubnagar goats. *Indian Journal of Animal Research* **44**(1): 48-51.

Gholizadeh, M., Mianji, G.R, Hashemi, M. and Hafezian, H. (2010). Genetic parameter estimates for birth and weaning weights in Raeini goats. *Czech Journal of Animal Science* **55**(1): 30-36.

Gowane, G.R., Chopra, A. and Prakash V. (2011). Estimates of (co) variance components and genetic parameters for growth traits in Sirohi goat. *Tropical Animal Health and Production* **43**: 189-198

Gul, S., Arzik, Y., Kizilaslan, M., Behrem, S. and Keskin M. (2023). Heritability and environmental influence on pre-weaning traits in Kilis goats. *Tropical Animal Health and Production* **55**(2): 85. https://doi.org/10.1007/s11250-023-03509-3.

Harvey, W.R. (1990). *User's guide for LSMLMW PC–2 Version. Mixed Model Least-Squares Maximum Likelihood Computer Program.* Ohio State University, Columbus, Ohio, USA.

Hassan, M. M., Mahmud, S.M.N., Islam, S.K.M.A. and Miazi, O.F. (2007). A comparative study on reproductive performance and productivity of the Black Bengal and cross goat at Atrai, Bangladesh. *Journal of Zoological Science* **26**: 55-57.

Islam, M.R., Saadullah, M., Howlider, A.R. and Huq, M.A. (1991). Estimation of live weight and dressed carcass weight from different body measurements in goats. *Journal of Animal Science* **61**(4): 460-461.

Jasmine, A.J., Sarkar, U., Roy, M. and Datta, S. (2022). Influence of genetic and non-genetic factors on growth performance in Black Bengal goats under field condition in West Bengal. *Indian Journal of Animal Science* **92**(10): 1194-1198.

Kramer, C.Y. (1957). Extension of multiple range tests to group correlated adjusted means. *Biometrics* **13**: 13-18.

Kumar, N., Kumari, N. and Shrivastava, A.K. (2021). A study of effect of sex, season, type, and parity of birth on absolute and relative body weight of Black Bengal goats at different ages under farm condition of management. *Journal of Entomology and Zoology Studies* **9**(1): 197-201.

Mandal, A., Behera, R., Bhusan, S. and Rout, P.K.

(2018). Factors affecting growth traits of Jakhrana goats in semi-arid region of India. *Indian Journal of Small Ruminants* **24**(1): 22-26.

Meyer K. (2007). WOMBAT: A tool for mixed model analyses in quantitative genetics by restricted maximum likelihood (REML). *Journal of Zhejiang University Science B* **8**(11): 815-821. https://doi.org/10.1631/jzus.2007.B0815.

Mia, M.M., Khandoker, M.A.M.Y., Husain, S.S., Faruque, M.O., Notter, D.R. and Haque, M.N. (2013). Genetic evaluation of growth traits of Black Bengal goat. *Iranian Journal of Applied Animal Science* **3**(4): 845-852.

Moghbeli, S.M., Barazandeh, A., Vatankhah, M. and Mohammadabadi M. (2013). Genetics and non-genetics parameters of body weight for post-weaning traits in Raini Cashmere goats. *Tropical Animal Health and Production* **45**: 1519-1524.

Mohammadi, H., Shahrebabak, M.M. and Shahrebabak, H.M. (2012). Genetic parameter estimates for growth traits and prolificacy in Raeini Cashmere goats. *Tropical Animal Health and Production* **44**: 1213-1220.

Singh, D., Kumar, R., Pander, B.L., Dhaka, S.S. and Singh, S. (2006). Genetic parameter of growth traits in crossbred sheep. *Asian-Australasian Journal of Animal Sciences* **19**(10): 1390-1393.

Singh, P., Singh, M.K. and Singh, S.K. (2013). Effect of nongenetic factors on body weights of Jamunapari goats. *Indian Journal of Small Ruminants* **19**: 146-150.