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Genetic and Non-Genetic Factors Affecting Post-Weaning Growth and Morphometric Traits in Assam Hill Goat

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ABSTRACT

The present work was conducted to evaluate the performance in respect of post-weaning growth and morphometric traits of Assam Hill goat. Data on 960 animals belonging to 3 populations of Assam Hill goat maintained at three field units *viz*., Batabari, Nahira and Tetelia under All India Coordinated Research Project on Goat Improvement were utilized. The least-squares means for body weight, height at withers, heart girth and body length were 7.557 ± 0.049 kg, 41.231 ± 0.121 cm, 44.621 ± 0.115 cm and 50.778 ± 0.172 cm at 6 months; 9.934 ± 0.044 kg, 43.902 ± 0.120 cm, 48.890 ± 0.099 cm and 55.552 ± 0.170 cm at 9 months and 12.549 ± 0.046 kg, 46.791 ± 0.112 cm, 52.765 ± 0.090 cm and 58.392 ± 0.207 cm at 12 months of age, respectively. Location had significant effect on body weight and height at withers at all age groups; on heart girth at 6, 9 and 12 months and on body length at 6 and 12 months of age. Season of birth exerted significant effect on body weight at 9 and 12 months; on height at withers at 12 months and on body length at 6, 9 and 12 months of age. Significant effect of sex was observed on body weight at 9 and 12 months, on height at withers at 6, 9 and 12 months and on heart girth and body length at 9 and 12 months of age. The heritability estimates for body weight and body measurements were moderate indicating scope of selection. The phenotypic and genetic correlation among body weights and body measurements at 6, 9 and 12 months of age were positive in direction and high in magnitude.

Key words: Assam Hill goat, Genetic parameters, Morphometric traits, Non-genetic factors, Post-weaning growth.

INTRODUCTION

Goat rearing is the backbone of economy of small and landless farmers in the state of Assam. It is an insurance against crop failure and provides alternate source of livelihood to farmers all the year round. Goats are among the main meat producing animals in the state where chevon is the meat of choice and has huge domestic demand. The indigenous goats of Assam known as 'Assam Hill Goat' are famous for their excellent meat quality, high prolificacy and adaptability to local environment. It is a small sized animal in which the predominant coat colour is white, but, black, brown and grey are also found.

Growth and development are important factors for production of meat animals. Body weight and body measurements are important parameters to describe growth (Salako, 2006). Post-weaning body weight is primarily affected by hereditary factors along with plane of nutrition, prevailing meteorological conditions and ability of the animal to adapt to its environment. In meat producing animals, external body measurements could be a reliable indicator of its future performance with respect to live body weights, if and only if a correlation has been identified among these traits of interest (Tomar *et al*., 2001). The potential of genetic improvement of the trait of interest is largely dependent on its heritability value and genetic relationship with other traits of economic importance upon which some selection pressure may be applied. Information on heritability is essential for planning efficient breeding programmes, and for prediction of response to selection (Falconer, 1989). The meat production of Assam Hill goat could be increased by augmenting the growth performance of the animals.

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Therefore, in the present study, an attempt was made to study the genetic and non-genetic factors affecting post-weaning body weights and morphometry of Assam Hill goat along with the genetic parameters.

MATERIALS AND METHODS

Location and data collection

The animals used in this study were reared by the farmers belonging to the field units under "All India Coordinated Research Project on Goat Improvement", Goat Research Station, Assam Agricultural University, Burnihat. The location lies between 90.48° and 92.22° (East) longitude and 20.09° and 26.95° (North) latitude. The data pertaining to 960 animals were utilized in the present investigation. Measurements of four morphological characters *viz*. body weight (BW), height at withers (HW), heart girth (HG) and body length (BL) were recorded at 6, 9 and 12 months of age. Measuring tapes were used to record the length and heart girth in cm, while heights were measured using graduated stick. The body weights were measured by using spring balance of 50 kg capacity in the morning hours. The data were classified into three locations *viz*., Batabari (L_1), Nahira (L_2) and Tetelia (L_3); four seasons of birth *viz*. pre-monsoon *i.e* March-May (S_1), Monsoon *i.e*. June-September (S_2), post-monsoon *i.e*. November-December (S_3) and winter *i.e*. December-February (S_4) and two sexes as male and female.

Management practices

The goat sheds were made of locally available materials *i.e*. bamboo, wood, thatches etc. The slotted floors of the houses were raised by about 3 feet. The walls of the shed were made of bamboo and covered up to 3/4th of the total height of the wall and rests of the portions were kept open for ventilation. The animals were kept under semi-intensive management system. Selective breeding was practised where the breeding does were mated with superior bucks supplied under the project. All the male kids except those kept for breeding purpose were castrated before 3 months of age. The animals were immunized regularly against enterotoxaemia, peste des petits ruminants and goat pox. Regular deworming was practised in all the field units under study.

Statistical methods

The data were analyzed by using least-squares technique as described by Harvey (1990). The statistical model used to analyze the data was $Y_{ijko} = \mu + L_i + M_j + S_k + e_{ijko}$, where, Y_{ijko} is the value of the oth animal in the (ijk)th sub-class, μ is the overall population mean, L_i is the effect of ith location (i=1, 2, 3), M_j is the effect of jth season of birth (j=1, 2, 3, 4), S_k is the effect of the sex of the kid (k=1, 2) and e_{ijko} is the random error associated with Y_{ijko} assumed to be NID (0, σ^2_e). Duncan's Multiple Range Test (DMRT), modified by Kramer (1957) was applied to make pair wise comparison among the means wherever significant differences exist.

The estimates of heritability (h^2), phenotypic (r_P) and genetic (r_G) correlations were calculated from the sire component of variance and covariance using methods described by Becker (1975). The statistical model used to estimate the genetic parameters was $Y_{ij} = \mu + S_i + e_{ij}$, where, Y_{ij} is the observed value of jth progeny on ith sire, μ is the overall population mean, S_i is the effect of ith sire common to all its progeny (i = 1,2,3.....) and e_{ij} is the random error component assumed to be NID (0, σ^2_e). Standard errors of heritability were estimated as per Swiger *et al*. (1964), while standard errors of phenotypic and genetic correlation were

Table 1: Least-squares means and standard errors for body weight (kg).

Effects	N	LSM ± SE		
		6 months	9 months	12 months
μ	960	7.557±0.049	9.934±0.044	12.549±0.046
Location				
L_1	212	7.687±0.099^a	9.960±0.088^a	12.313±0.092^a
L_2	335	7.774±0.080^a	10.222±0.071^b	12.659±0.074^b
L_3	413	7.210±0.072^b	9.621±0.064^c	12.673±0.067^b
Season of birth				
S_1	254	7.492±0.091	10.076±0.081^a	12.680±0.084^a
S_2	280	7.565±0.088	9.973±0.079^a	12.622±0.082^a
S_3	150	7.702±0.117	10.072±0.105^a	12.639±0.109^a
S_4	276	7.468±0.087	9.670±0.078^b	12.254±0.081^b
Sex				
Male	513	7.575±0.066	10.258±0.058^a	13.068±0.061^a
Female	447	7.539±0.070	9.610±0.062^b	12.030±0.065^b

N = Number of observation, LSM = Least-squares mean, SE = Standard error.

Means of a subclass with at least one superscript in common do not differ significantly from each other (P<0.05).

Table 2: Least-squares analysis of variance for body weight.

Sources of variation	df	MS		
		6 months	9 months	12 months
Location	2	32.760*	32.906**	10.312*
Season of birth	3	2.043	7.978*	9.861*
Sex	1	0.310	19.69**	24.98**
Error	953	10.47	2.96	3.75

*P<0.05, **P<0.01

estimated as per the methods of Panse and Sukhatme (1969) and Robertson (1959), respectively.

RESULTS AND DISCUSSION

The estimates of least-squares means (LSM) and standard errors (SE) for body weight, height at withers, heart girth and body length at 6, 9 and 12 months of age are presented in Tables 1, 3, 5 and 7, respectively. Least-squares analyses of variance showing the effect of different factors on the traits are presented in Table 2, 4, 6 and 8, respectively.

Body weight

The overall LSM ± SE for body weight at 6, 9 and 12 months of age were 7.557 ± 0.049 kg, 9.934 ± 0.044 kg and 12.549 ± 0.046 kg, respectively (Table 1), which are in concordance with the findings of Nahardeka (1994) in Assam Local goats. Lower value (5.96 ± 0.49 kg at 6 months of age by Sarma, 1997) and higher values (8.02 ± 2.17 kg, 10.92 ± 2.72 kg and 14.47 ± 3.55 kg, respectively at 6, 9 and 12 months of age by Mia *et al.*, 2013) were reported respectively in Assam Local and Black Bengal goats.

Effect of location

Location had significant effect on body weight in all age groups (Table 2). Goats of Tetelia unit exhibited comparatively higher body weights at 12 months of age. Better health care and management, availability of feed, better financial condition of the farmers and awareness might have aided to the rise in the body weights of the goats of Tetelia unit.

Effect of season of birth

Non-significant effect of season of birth was observed on body weight at 6 months of age (Table 2), which is in agreement with the observations of Singh (1991) in Assam Local goats. However, significant effect was reported by Paul *et al.* (2014) in Black Bengal goats. Differences in the body weight at 9 and 12 months of age due to season of birth were found to be significant (P<0.05) in the present study (Table 2), which are supported by the findings of Paul *et al.* (2014) in Black Bengal goats. The higher body weight at 9 and 12 months of age for the goats kidded during pre-monsoon season might be due to exposure to better environmental conditions in terms of feeds, green fodder, low heat stress and other management practices. However, non-significant effect of season of birth was obtained by Singh (1991) in Assam Local goats on both the traits.

Effect of sex

Analysis of variance revealed that body weight at 6 months of age was not significantly affected by sex of kids though the weights of male kids were higher than the females

Table 3: Least-squares means and standard errors for height at withers (cm).

Effects	N	LSM ± SE		
		6 months	9 months	12 months
µ	960	41.231±0.121	43.902±0.120	46.791±0.112
Location				
L_1	212	42.261±0.241^a	44.379±0.239^a	47.508±0.224^a
L_2	335	40.811±0.195^b	43.662±0.194^b	47.187±0.181^a
L_3	413	40.622±0.176^b	43.667±0.175^b	45.679±0.163^b
Season of birth				
S_1	254	41.218±0.221	43.857±0.220	46.474±0.205^a
S_2	280	41.346±0.215	43.977±0.214	47.211±0.200^{bc}
S_3	150	41.216±0.286	43.955±0.284	46.958±0.266^{ab}
S_4	276	41.144±0.213	43.821±0.212	46.522±0.298^a
Sex				
Male	513	42.235±0.160^a	44.996±0.159^a	48.013±0.148^a
Female	447	40.227±0.170^b	42.808±0.170^b	45.569±0.158^b

N = Number of observation, LSM = Least-squares mean, SE = Standard error.

Means of a subclass with at least one superscript in common do not differ significantly from each other (P<0.05).

Table 4: Least-squares analysis of variance for height at withers.

Sources of variation	df	MS		
		6 months	9 months	12 months
Location	2	201.909**	42.068*	38.126*
Season of birth	3	1.911	1.401	32.155*
Sex	1	48.389*	80.073**	81.398**
Error	953	12.158	12.041	10.503

*P<0.05, **P<0.01.

(Table 2). Similar observations were obtained by Naik *et al.* (1985) in Ganjam goats. However, significant effect (P<0.01) was reported by Mehta *et al.* (1997) in Sirohi goats. On the other hand, the present study revealed significant differences (P<0.01) in body weight at 9 and 12 months of age due to sex (Table 2). These confirmed the earlier reports of Paul *et al.* (2014) in Black Bengal goats. The increase in body weight of male goats might be attributed to the early activation of male gonads than the females. Male sex hormone testosterone, responsible for the anabolic effect could have caused the faster growth in male animals.

However, non-significant effect of sex on body weight at 9 and 12 months of age were reported by Naik *et al.* (1985) in Ganjam goats.

Height at withers, heart girth and body length

The overall LSM ± SE for height at withers, heart girth and body length were 41.231 ± 0.121 cm, 43.902 ± 0.120 cm and 46.791 ± 0.112 cm at 6 months; 44.621 ± 0.115 cm, 48.890 ± 0.099 cm and 52.765 ± 0.090 cm at 9 months; and 50.778 ± 0.172 cm, 55.552 ± 0.170 cm and 58.392 ± 0.207 cm at 12 months of age, respectively (Table 3, 5 and 7). These findings were in accordance with the findings of Pan *et al.* (2015) in Black Bengal goats for height at withers and heart girth and Saikia *et al*. (1985) in Assam Local goats for body length. However, much higher values were recorded in Sirohi goats by Dudhe *et al.* (2015).

Effect of location, season of birth and sex of kids on morphometric traits

Location affected height at withers and heart girth significantly (P<0.01 at 6 months and P<0.05 at 9 and 12 months of age in case of height at withers; and P<0.05 at 6 and 12 months and P<0.01 at 9 months of age in case of heart girth) in all age groups, but body length at 6 (P<0.05) and 12 months (P<0.05) of age only (Table 4, 6 and 8).

Least-squares analysis of variance revealed significant effect of season of birth (P<0.05) on height at withers at 12 months of age only, but on body length (P<0.01) at all age groups (Table 4 and 8). The values for height at withers were found to be comparatively higher in animals born during monsoon season and values for body lengths were comparatively higher in goats born during post-monsoon season. The results are in accordance with the findings of Dudhe *et al*. (2015) in Sirohi goats. On the other hand, observations contradictory to the present findings were reported by Das *et al.* (1989) in Barbari goats. However, in the present investigation, non-significant effect of season of birth was observed on heart girth at all age groups (Table 6), while, significant effect was observed by Dudhe *et al.* (2015) in Sirohi goats.

Sex of kids' exerted significant effect (P<0.05 at 6 months and P<0.01 at 9 and 12 months of age) on height at withers at all the age groups; while on heart girth (P<0.05

Table 5: Least-squares means and standard errors for heart girth (cm).

Effects	N	LSM ± SE		
		6 months	9 months	12 months
μ	960	44.621±0.115	48.890±0.099	52.765±0.090
Location				
L_1	212	44.252±0.229[a]	48.214±0.198[a]	53.547±0.179[a]
L_2	335	45.203±0.185[b]	49.663±0.160[b]	52.448±0.145[b]
L_3	413	44.407±0.167[a]	48.796±0.144[c]	52.300±0.131[b]
Season of birth				
S_1	254	44.849±0.210	49.247±0.181	52.654±0.164
S_2	280	44.697±0.204	48.257±0.177	52.924±0.160
S_3	150	44.296±0.272	48.590±0.235	52.721±0.212
S_4	276	44.643±0.202	48.970±0.175	52.760±0.158
Sex				
Male	513	44.653±0.152	49.981±0.131[a]	54.160±0.119[a]
Female	447	44.590±0.162	47.801±0.140[b]	51.370±0.127[b]

N = Number of observation, LSM = Least-squares mean, SE = Standard error.

Means of a subclass with at least one superscript in common do not differ significantly from each other (P<0.05).

Table 6: Least-squares analysis of variance for heart girth.

Sources of variation	df	MS		
		6 months	9 months	12 months
Location	2	34.292*	146.077**	22.408*
Season of birth	3	9.787	16.955	3.414
Sex	1	0.946	31.941*	44.615**
Error	953	10.991	8.211	6.709

*P<0.05, **P<0.01.

Table 7: Least-squares means and standard errors for body length (cm).

Effects	N	LSM ± SE		
		6 months	9 months	12 months
μ	960	50.778±0.172	55.552±0.170	58.392±0.207
Location				
L_1	212	49.917±0.343[a]	55.263±0.339	57.693±0.412[a]
L_2	335	51.607±0.277[b]	55.851±0.274	58.423±0.334[ab]
L_3	413	50.810±0.251[c]	55.542±0.248	59.059±0.301[b]
Season of birth				
S_1	254	50.888±0.315[a]	55.629±0.311[a]	58.343±0.378[a]
S_2	280	51.778±0.306[b]	56.581±0.303[b]	59.399±0.368[b]
S_3	150	51.982±0.407[b]	56.591±0.403[b]	59.415±0.490[b]
S_4	276	48.464±0.303[c]	53.543±0.300[c]	56.411±0.365[c]
Sex				
Male	513	50.928±0.228	56.333±0.225[a]	59.134±0.274[a]
Female	447	50.628±0.243	54.771±0.240[b]	57.649±0.292[b]

N = Number of observation, LSM = Least-squares mean, SE = Standard error.
Means of a subclass with at least one superscript in common do not differ significantly from each other (P<0.05).

Table 8: Least-squares analysis of variance for body length.

Sources of variation	df	MS		
		6 months	9 months	12 months
Location	2	79.855*	23.006	132.112*
Season of birth	3	643.899**	500.384**	496.094**
Sex	1	21.570	161.623**	237.664**
Error	953	24.723	24.195	35.739

*P<0.05, **P<0.01

Table 9: Estimates of heritability (h^2), phenotypic (r_P) and genetic (r_G) correlation of body weight at 6, 9 and 12 months of age.

r_P / r_G	6 months	9 months	12 months
6 months	0.1782±0.089	0.7592±0.105	0.6582±0.011
9 months	0.7609±0.137	0.3210±0.137	0.4597±0.037
12months	0.8550±0.088	0.7080±0.151	0.3157±0.135

N.B. The elements of the diagonal are the estimates of heritability, above the diagonal are the phenotypic correlations and below the diagonal are the genetic correlation.

Table 10: Estimates of heritability (h^2), phenotypic (r_P) and genetic (r_G) correlation between body weight and body measurements at 6 months of age.

r_P / r_G	BW	HW	HG	BL
BW	0.1782±0.089	0.3698±0.031	0.4364±0.032	0.8269±0.010
HW	0.3212±0.300	0.4221±0.168	0.4483±0.032	0.4337±0.026
HG	0.4392±0.335	0.3200±0.297	0.2429±0.111	0.4863±0.032
BL	0.3973±0.283	0.5185±0.277	0.3733±0.275	0.4776±0.185

N.B. The elements of the diagonal are the estimates of heritability, above the diagonal are the phenotypic correlations and below the diagonal are the genetic correlations.

Table 11: Estimates of heritability (h^2), phenotypic (r_P) and genetic (r_G) correlation between body weight and body measurements at 9 months of age.

r_P / r_G	BW	HW	HG	BL
BW	0.3210±0.137	0.3414±0.029	0.5512±0.032	0.2356±0.017
HW	0.3812±0.261	0.2849±0.125	0.8963±0.032	0.4356±0.002
HG	0.3501±0.270	0.4619±0.246	0.2676±0.119	0.6253±0.032
BL	0.2383±0.276	0.4013±0.294	0.4873±0.275	0.4029±0.162

N.B. The elements of the diagonal are the estimates of heritability, above the diagonal are the phenotypic correlations and below the diagonal are the genetic correlations.

Table 12: Estimates of heritability (h^2), phenotypic (r_P) and genetic (r_G) correlation between body weight and body measurements at 12 months of age.

r_P / r_G	BW	HW	HG	BL
BW	0.3157±0.135	0.5362±0.004	0.7234±0.032	0.5604±0.046
HW	0.3095±0.286	0.3482±0.145	0.3853±0.028	0.3171±0.016
HG	0.3492±0.285	0.7874±0.109	0.4363±0.172	0.5518±0.032
BL	0.7012±0.260	0.3396±0.261	0.4325±0.265	0.5757±0.212

N.B. The elements of the diagonal are the estimates of heritability, above the diagonal are the phenotypic correlations and below the diagonal are the genetic correlations.

and P<0.01) and body length (P<0.01) the significant effects were observed at 9 and 12 months of ages (Table 4, 6 and 8). The values of the least-squares means for male animals were higher than those for the females. These results were supported by the reports of Dudhe *et al.* (2015) in Sirohi goats. However non-significant effect was reported by Kharkar *et al.* (2014) in Berari goats.

Genetic parameters

The estimates of genetic parameters *viz.*, heritability (h^2), phenotypic correlation (r_P) and genetic correlation (r_G) along with the standard errors among body weights and body measurements at 6, 9 and 12 months of age are presented in Table 9-12.

Heritability

The heritability estimates for body weights under study were moderate (Table 9). These estimates are in agreement with the estimates of Nahardeka *et al.* (2001) in Assam Local goats for body weight at 6 months and Moghbeli *et al.* (2013) in Raini Cashmere goats for body weights at 9 and 12 months of age. The estimates of heritability obtained in the present study indicated the scope for improvement of the traits through selection. However, lower (0.070 ± 0.020, 0.120 ± 0.040 and 0.130 ± 0.040 at 6, 9 and 12 months of age, respectively) and higher (0.450 ± 0.070, 0.490 ± 0.060 and 0.470 ± 0.080 at 6, 9 and 12 months of age, respectively) estimates of heritability for these traits were obtained by Gowane *et al.* (2011) in Sirohi goats and Mia *et al.* (2013) in Black Bengal goats.

Similarly, moderate estimates of heritability for height at withers, heart girth and body length at 6, 9 and 12 months of age were obtained in the present study which also indicated scope of improvement by selection (Table 10, 11 and 12). However, Dudhe *et al.* (2015) reported higher estimates (0.709 ± 0.144, 0.699 ± 0.179, 0.708 ± 0.188 for height at withers; 0.563 ± 0.138, 0.676 ± 0.184, 0.503 ± 0.197 for heart girth and 0.589 ± 0.150, 0.571 ± 0.172, 0.605 ± 0.192 for body length) of heritability for morphometric traits in Sirohi goats as compared to the present estimates.

Phenotypic and genetic correlation

The phenotypic and genetic correlations among body weights were found to be positive and high at all age groups (Table 9). It has considerable significance in the selection programme for body weight, since body weight at early ages is a good indication of body weight at 12 months of age. The findings are in conformity with the findings of Mia *et al.* (2013) in Black Bengal goats.

The phenotypic and genetic correlations among body weights and various body measurements were found to be positive and high at all age groups (Table 10, 11 and 12). This indicated that the linear body measurements could reliably play a predictive role for body weight at any given age. Body weight appeared to be a function of these body measurements. Further, it also indicates the possibility of improving body weight as a correlated response by exerting selection pressure on the body measurements. Dudhe *et al.* (2015) in Sirohi goats also reported positive and high phenotypic and genetic correlation among body measurements as obtained in the present study.

CONCLUSION

The present study has revealed the importance of some non-genetic factors for growth performance which could be utilized for genetic evaluation. The effects of location, season of birth and sex were found to be significant for most of the parameters; heritability estimates of growth traits were moderate and phenotypic and genetic correlations were also positive and high. Therefore, it could be concluded that there is scope of selection based on morphometry and animals with higher body weights at initial phases of growth will perform better with respect to growth traits at later stages. These results, therefore, provide an important perspective on the selection objectives of Assam Hill goats by considering different environmental factors. Since body weight and body measurements are important parameters to describe growth, so, selective breeding of Assam Hill goat based on these parameters needs to be given more emphasis in breeding programmes for greater productivity.

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