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Correlations among Certain Growth and Production Traits in Different Breeds of Goats

Research Article

R. Khandaker[1], M.K.I. Khan[1*] and M.M. Momin[1]

[1] Department of Genetics and Animal Breeding, Chittagong Veterinary and Animal Science University Khulshi, Chittagong-4225, Bangladesh

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*Correspondence E-mail: kik1775@yahoo.co.uk

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ABSTRACT

The study was conducted to estimate the genetic and phenotypic correlations among body measurements, body weight, kidding interval, kidding rate and milk yield in the different breeds of goat. Data was collected on 95 goats of three breeds (Jamunapari, Black Bengal and their crosses (Jamunapari×Black Bengal) through direct observation. The average body weight of Jamunapari goat was 34.75 ± 3.33 kg higher than Black Bengal (27.54 ± 5.332 kg) goats. It was observed that Jamunapari goat (0.65 ± 0.187 L/day) produces higher daily milk during lactation length than Black Bengal (0.50±0.094 L/day), leading to higher lactation milk production of this goat. The kidding rate and kidding interval were 1.33 ± 0.466 and 223.27 ± 11.19 days in Jamunapari, 1.475 ± 0.555 and 247.94 ± 17.23 days in crossbred, 1.75 and 160.83 ± 16.57 days in Black Bengal goats, respectively. The heritability estimates of body weight, milk yield and lactation milk yield were 0.29 to 0.32, 0.25 to 0.20 and 0.30 to 0.32 for all breeds of goat. The genetic correlation (r_g) and phenotypic correlation (r_p) of body weight were positive with all traits except the r_g with lactation yield. The body length had negative r_p with lactation production and negative r_g with daily milk yield and lactation production. The body height has negative r_p with kidding rate, kidding interval, milk yield and lactation production and positive r_g only with kidding interval in all breeds. The high and positive correlations (either genetic or phenotypic) are important predictors of traits for improvement. Hence, these can be valuable tools for making selection/culling decisions for improved productivity of goats.

KEY WORDS correlations, (co)variances, different traits, goats, heritability.

INTRODUCTION

Goat is an important species for the poor and landless people, especially in South East Asia including Bangladesh, due to its smaller body size, quick return and less capital investment. The population of goats in Bangladesh is 25.21 million (DLS, 2013). Among the total goat population 90% of the goat are Black Bengal and remaining 10% are Jamunapari and others (Faruque and Khandoker, 2007). Generally, goat plays an important role in generating employment for landless and destitute women, income and improving household nutrition. Goat farming can be used as effective tool for poverty reduction as it require less investment and less feeding and management costs than large animal farming (Khan and Naznin, 2013). Goats of Bangladesh are grazes on barren and road-side land grass and feed with available least cost roughages like neem tree (*Azadirachta indica*) leaves, mango (*Mangifera indica*) leaves, jackfruit (*Artocarpus heterophyllus)* leaves, and concentrates: rice gruel, rice polish, cooked rice and sometime various brans. The genetic erosion in goat's resources is occurring due to unsystematic breeding and to overcome it, a structured genetic improvement program should be undertaken with specific breeding goals. The main aim of

breeding-selection is to produce new generations which would exceed in performance over previous generation in production of milk and meat (Pantelic *et al.* 2008; Kapell *et al.* 2009). For construction of selection index the knowledge of the breeding values along with estimates of genetic and phenotypic correlation and heritability of different traits is essential. Several studies (Khan and Naznin, 2013; Khan and Khatun, 2013; Talukder *et al.* 2010) were conducted on the productive and reproductive parameters of goats of Bangladesh. However, studies on the breeding objectives and genetic correlations between economic traits are very limited in these goats. Genetic and phenotypic correlations have great importance in intermediary or indirect selection when changes in one trait are induced through selection for other trait where a genetic correlation exists. Therefore, the present study was designed to focus on the association among traits with the aim of identifying relevant correlations that can be used in further selection process.

MATERIALS AND METHODS

Sources of data

The farm houses and goat rearing farmers were selected from Podia Upazila at Chittagong district of Bangladesh by visiting the area frequently. On the basis of the breed characteristics (phenotypic) a total of 95 goats from three different genotypes (35 for Black Bengal, 25 for Jamunapari and 35 crossbred (Jamunapari×Black Benal)) were chosen based on age, body shape and size and live weight. The selected goats were categorized based on their age and lactation numbers under a breed. The goats were allowed for normal feeding and management under subsistence production system.

Productive and reproductive traits of different goat breeds

The data recording was started from the date of conception up to parturition to know the kidding rate and from kidding to next batch of kidding to calculate the kidding interval. The mature body weight of the doe was recorded using a top loading balance. The body height and body length of the goats were taken by measuring tape. Milk production per goat per lactation was collected on a test day basis at a weekly interval from individual goat. For milk yield data, kids were separated from their dams overnight (12 hours) preceding the day of milk recording then the kids were allowed for milk consumption and the amount of milk production was estimated as the difference between the body weight before and after sucking of kid. The lactation length of each goat was calculated by counting from the date of kidding up to the date of milk withdrawal. The milk production was calculated by multiplying average daily milk yield with lactation length.

Genetic and phenotypic correlations between traits

Phenotypic correlations among different traits were calculated by Pearson (1905) formula for estimation of genetic correlations, the heritability values of the traits were first estimated by a univariate animal model using AIREML (average information restricted maximum likelihood) (Johnson and Thompson, 1995). The model of the study was as:

$$Y = Xb + Zu + e$$

Where:
Y: vector of observations for all traits.
b: vector of common fixed effects due to farm, test group and breed.
u: vector of random genetic effects.
e: vector of residuals.
X and Z: incidence matrices relating observations to the fixed and random (animal) effects.

After obtaining the heritability of each trait, the mean value for the traits was calculated and the breeding value of each trait was estimated as:

$$BV = h^2(X - \bar{X})$$

Where:
BV: breeding value of each trait.
h^2: heritability.
X: individual trait.
$\bar{X}$: average of the trait.

Then the genetic correlation between breeding values of two successive traits was calculated.

Statistical analysis

Least squares means were estimated for fixed effects: breed, age and lactation numbers using PROC GLM and PROC MIXED of SAS (SAS, 2008). The statistical model for analysis was:

$$Y_{ijkm} = \mu + B_i + A_j + L_k + e_{ijkm}$$

Where:
Y_{ijkm}: measurement on a particular trait.
μ: population mean.
B_i: random effect of i^{th} breed (i=3 breed i.e. Jamunapari, crossbred, Black Bengal).
A_j: fixed effect of age (j=1, 2, 2.5, 3 and 3.5 years).
L_k: fixed effect of lactation number (k=1, 2 and 3).
e_{ijkm}: random error, associated with each record, distributed as N (0, σ^2).

The mean value was compared using the least significant difference (LSD) test at P= 0.05 (Steel *et al.* 1997).

RESULTS AND DISCUSSION

Productive and reproductive performance of three different goat breeds:

The Jamunapari goat produced maximum average daily milk yield (0.65 kg/day) and a longer lactation length (142.02 days) than Black Bengal (0.5 kg/day) goats and its crosses produced intermediate which leads to higher lactation production of Jamunapari goat (Table 1). Similar amount of milk yield for Jamunapari and Black Bengal goat was recorded by Hassan *et al.* (2010) and Paul *et al.* (2014). However, Jamunapari goat produces more milk and heavier than Black Bengal goat this might be the breed characteristics of this goat these finding are supported with Bhowmik *et al.* (2013).

However, within age and lactation number groups, the Jamunapari goat have shown significant differences for lactation length, but for other traits, no variation was observed.

For crossbred, no difference was observed for lactation length for age and lactation numbers but other two traits were varied. In case of Black Bengal goat, the age group within breed shown difference in lactation length, but remaining two traits showed no variation. It was observed that two years aged Black Bengal goat produces higher milk than one and three years old. Similar trends were also observed in Jamunapari goats also. Jamunapari and Black Bengal goats produced more milk during two to three lactations.

Olechnowicz and Sobek (2008) also reported that goats produces more milk during two to three lactations.

The body weight of the three studied breeds was not differed statistically; however, numerically Jamunapari (34.75 kg) was higher than crossbred (32.03 kg) and Black Bengal (28.79 kg) goats.

Higher body weight of Jamunapari goat might be due to breed characteristics. However, Bhowmik *et al.* (2013) observed the higher body weight for Jamunapari (45.47±3.78 kg) and crossbred goats (35.72±2.97 kg), than present study however Rahman (2007) and Paul *et al.* (2011) reported the similar body weights of goats in their study.

Table 1 Production and reproductive performance of three different breeds of goat in respect of age and lactation numbers

Breed	Age	LN	MY (kg/day)	LL (days)	LP (kg)	Lwt (kg)	KR	KI (days)
Jamunapari	1	1	0.5 ±0.360(3)	140^{b} ±10(3)	73.6 ±47.692(3)	29.33^{b} ±2.081(3)	1.66 ±0.577(3)	226.66 ±20.816(3)
	2	1	1.13^{a} ±0.351(3)	133.33^{c} ±7.637(3)	152.26 ±62.151(3)	33.33^{c} ±2.516(3)	2^{a} (3)	223.13 ±5.773
	2.5	2	0.43^{b} ±0.17(7)	139.28^{ac} ±5.763(8)	53.73(13)	35.07^{c} ±1.427(8)	1.86 ±0.243(8)	228.57 ±6.90(8)
	3	2	0.56 ±.057(3)	177.25^{a} ±13.301(4)	79.46 ±11.582(3)	38^{a} ±7.788(4)	1.5 ±0.577(4)	212.5 ±18.929(4)
	3.5	3	0.65 (2)	139.5^{b}(3)	85.35(2)	38^{a}±2.8(3)	1.5^{b} (3)	225.5±3.5(3)
Breed average			0.65^{a} ±0.187	144.02^{a} ±6.09	88.48 ±22.88	34.75 ±3.33	1.33 ±0.466	223.27^{b} ±11.19
Crossbred	2	1	0.7^{b} (2)	101.75 ±6.968(6)	162.95^{a}(2)	33.35 ±0.774(5)	2 (5)	239.38^{b} ±4.269(5)
	2.5	2	0.9^{a}(1)	115 ±8.027(3)	114.4 (1)	32.16 ±2.753(3)	1.33 ±.577(3)	246.66 ±25.166(3)
	3	2	0.48^{ab} ±0.327(5)	110 ±16.329(7)	52.66^{b} ±34.583(5)	30.42 ±3.952(3)	1.57 ±0.534(7)	245.71 ±22.253(7)
	3.5	3	0.3^{c}(1)	110 (1)	33.7 (1)	32.2 (1)	1(1)	260^{a}(1)
Breed average			0.57^{ab} ±0.082	107.75^{b} ±7.62	61.42 ±8.65	32.03 ±1.87	1.475 ±0.555	247.94^{a} ±17.23
Black Bengal	1	1	0.5(1)	88.33^{abc} ±7.637(3)	80.6 (1)	25.66^{b} ±2.886(3)	2 (3)	158.33 ±16.072(3)
	2	1	0.4 ±0.282(2)	85^{b}(2)	55.05 ±0.282(2)	23.5^{ab} ±7.778(2)	2 (2)	165 ±17.07(2)
	2.5	2	-	80^{c}(1)	-	31^{a} (1)	2 (1)	150 (1)
	3	3	0.6 (1)	90^{a}(1)	80.6 (1)	30^{a}(1)	1 (1)	170 (1)
Breed average			0.50^{b} ±0.094	85.83^{c} ±1.909	72.08 ±0.094	27.54 ±3.554	1.75	160.83^{ab} ±11.04

LN: lactation number; MY: milk yield; LL: lactation length; LP: lactation production; Lwt: live weight; KR: kidding rate and KI: kidding interval.
The significant test showed between breed, between age within breed and between lactation within age and breed.
Parenthesis indicates the number of goat studied.
The means within the same row with at least one common letter, do not have significant difference (P>0.05).

The body weight of goats was changed with the changes of age and / or lactation numbers within breeds. For Jamunapari and Black Bengal goats higher body weight was obtained at the year 3 to 3.5 of age but no differences was found in case of crossbred.

For kidding rate among three different breeds, no significant difference was observed within breed between age and but differed in lactation numbers (Table 1). The kidding rate of Black Bengal, Jamunapari and crossbred goats was 1.75, 1.33 and 1.48, respectively. Numerically higher kidding rate of Black Bengal goat proves its reputation of high fecundity. The variations were due to the differences of breed, age of goats, feeding and managements of estrus. Khan and Khatun (2013) observed kidding rate for Black Bengal goat was 1.50 to 1.17. However, Rout *et al.* (1999) observed the kidding rate for Jamunapari was 1.60. The factors for variation of kidding rate were similar like milk yield. The kidding interval differed within breed between age and lactation numbers for crossbred only. Kidding interval of Black Bengal goat was lower (161 days) in other word the reproductive performance was better in Black Bengal goat than Jamunapari (223 days) and crossbred (248 days). Khan and Khatun (2013) and Talukder *et al.* (2010) observed higher kidding interval than the current study for Black Bengal goat they found kidding interval for Black Bengal goat was 172 to 188 days. The kidding interval was also dependent upon the age of the goats and also the length of post partum heat period. Season of previous kidding and period of kidding had significant effects on the intervals between successive kidding. In second and third lactation the kidding interval was higher due to ages of the goats. Similar factors were responsible to increase Kidding interval reported by Bhowmik *et al.* (2013).

Body length and body height of different breeds of goat in respect of age and lactation number

The crossbred goat (57.02 cm) had the highest body length than Jamunapari and Black Bengal goat (Table 2). For the age group of crossbred goat there is no significant differences were observed in body length and body height but the age groups of Black Bengal goat within breed showed significantly different body length and body height. Usually the body length and height is used to estimate the body weight of the animals. Luo *et al.* (1997) and Janssens and Vandepitte (2004) also reported difference of these measurements within breed and between age group. Body measurements are the key indicator of milk production in goats stated by Khan (2010). The result of present study was higher than Mandal *et al.* (2008) and similar with Bingol *et al.* (2012). The variation of body length might be due to breed and environmental differences.

Heritability, genetic and phenotypic correlations between different traits of different goats

Heritability, genetic and phenotypic correlations between different traits of Jamunapari, crossbred and Black Bengal goats are presented in Table 3.

The heritability of all the traits was positive (Table 3). In Jamunapari, crossbreds and Black Bengal goat the heritability, phenotypic correlations and genotypic correlations of milk yield and lactation production was ranged from 0.20 to 0.23 and 0.29 to 0.31, 0.96 to 0.98 and 0.994 to 0.96, respectively.

This indicated that milk yield had the positive correlation with lactation production. Bagnicka *et al.* (2004) reported the heritability values of milk yield from 0.19 to 0.324 and phenotypic correlation 0.247 to 0.355.

Table 2 Body length and body height of three different breeds of goat in respect of age and lactation numbers

Breed	Age	Lactation numbers	Body length (cm)	Body height (cm)
Jamunapari	1	1	43.18±4.399(3)	50.02±5.865(3)
	2	1	50.8±9.169(3)	50.02±6.391(3)
	2.5	2	50.62±3.315(8)	60.58±3.327(8)
	3	2	55.55±8.057(4)	61.59±8.89(4)
	3.5	3	57.79±0.899(3)	65.41±0.899(3)
Breed average	-	-	51.58^{b}±5.169	60.02±5.072
Crossbred	2	1	52.71±1.27(5)	60.33±0.734(5)
	2.5	2	54.18±2.931	61.80±3.918(3)
	3	2	57.68±2.824(7)	64.95±4.831(7)
	3.5	3	63.5(1)	66.04 (1)
Breed average	-	-	57.02^{a}±1.496	63.27±3.149
Black Bengal	1	1	43.18^{c}±2.54(3)	54.18^{a}±1.466(3)
	2	1	49.53^{a}±1.796(2)	58.42±3.592(2)
	2.5	2	43.18^{b}(1)	58.42^{b}(1)
	3	3	50.8^{ac}(1)	63.5^{c}(1)
Breed average	-	-	46.69^{b}±2.167	58.62±2.529

The significant test showed between breed, between age within breed and between lactation within age and breed.
Parenthesis indicates the number of goat studied.
The means within the same row with at least one common letter, do not have significant difference (P>0.05).

Table 3 Heritability, genetic and phenotypic correlations among traits of different genotypes of goat. Genetic correlation is shown below diagonal, heritability on the diagonal (bold) and phenotypic correlation above diagonal

	LWT	BLN	BHT	KI	KR	MY	LP
Jamunapari							
LWT	**0.312**	0.591	0.506	0.416	0.378	0.243	0.166
BLN	0.591	**0.162**	0.827	0.2113	0.150	0.0071	-0.0317
BHT	0.506	0.87	**0.05**	-0.0388	-0.069	-0.124	-0.176
KI	0.364	0.273	0.055	**0.013**	0.882	0.763	0.725
KR	0.280	0.147	-0.0087	0.665	**0.02**	0.733	0.738
MY	0.092	-0.076	-0.092	0.494	0.459	**0.25**	0.980
LP	-0.0022	-0.103	-0.160	0.441	0.496	0.966	**0.32**
Crossbred							
LWT	**0.302**	0.802	0.761	0.643	0.225	0.441	0.442
BLN	0.802	**0.154**	0.903	0.599	0.204	0.139	0.132
BHT	0.761	0.903	**0.04**	0.755	0.445	0.274	0.269
KI	0.555	0.433	0.462	**0.012**	0.767	0.652	0.643
KR	-0.218	-0.223	0.0043	0.043	**0.02**	0.534	0.521
MY	0.248	-0.081	-0.033	0.282	0.022	**0.23**	0.971
LP	0.251	-0.084	-0.029	0.289	0.018	0.942	**0.31**
Black Bengal							
LWT	**0.292**	0.767	0.839	0.509	0.497	0.372	0.385
BLN	0.767	**0.142**	0.919	0.467	0.526	0.016	-0.013
BHT	0.839	0.919	**0.03**	0.354	0.422	-0.018	-0.045
KI	0.386	0.386	0.324	**0.01**	0.892	0.705	0.699
KR	0.296	0.432	0.394	0.437	**0.018**	0.609	0.564
MY	0.131	-0.313	-0.268	0.254	0.047	**0.20**	0.977
LP	0.152	-0.347	-0.3004	0.256	-0.062	0.958	**0.30**

LWT: live weight; BLN: body length; BHT: body height; KI: kidding interval; KR: kidding rate; MY: milk yield and LP: lactation production.

The heritability value of body weight ranged from 0.29 to 0.32 for Black Bengal, crossbred and Jamunapari goats respectively (Table 3). Estimated heritability value for body weight was lower compared with Otuma and Osakwe (2008) and Khan (2010), who found heritability value of 0.42 for Sahelian goats and Beetal goats, respectively. The high and positive correlations (either genetic or phenotypic) among various traits are important predictor for attempting animal improvement (productive and reproductive performance). More specially, in case of milk yield positive and higher correlation with other productive and reproductive traits must be valuable tools for making selection/culling decision. Besides this, decision on other management factor/tools should take in account for improvement of animal.

CONCLUSION

It can be concluded that the Jamunapari goat produced higher daily average milk and higher lactation yield than Black Bengal and crossbred produced moderate. The kidding rate and kidding interval of Black Bengal goats were also better than Black Bengal breeds. The heritability value of body weight, milk yield and lactation production were moderate for all traits in all three breeds. The genotypic and phenotypic correlations of body weight and milk yield were positive with all traits except genetic correlation of body weight and lactation production which was negative.

The body length and height had negative phenotypic correlation with lactation production and negative genetic correlation with milk yield and lactation production in all three breeds. However, these two traits had negative phenotypic correlation with kidding rate, kidding interval, milk yield and lactation production and positive genetic correlation only with kidding interval in all breeds.

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REFERENCES

Bagnicka E., Distl O., Hamann H. and Lukaszewicz M. (2004). Heritabilities and genetic correlations between the dairy traits in goats estimated in first vs later lactations. *Anim. Sci. Pap. Rep.* **2,** 205-213.

Bhowmik N., Mia M.M., Rahman M.M. and Islam S. (2013). Preliminary study on productive and reproductive performances of Jamunapari, Black Bengal and crossbred goats at Chittagong region of Bangladesh. *Iranian J. Appl. Anim. Sci.* **4,** 89-93.

Bingöl M., Gökdal O., Aygün T. and Daşkiran I. (2012). Some productive characteristics and body measurements of Norduz goats of Turkey. *Trop. Anim. Health. Prod.* **44,** 545-452.

DLS. (2013). Development and Work Plan. Department of Livestock Services, Ministry of Livestock and Fishery, Dhaka, Bangladesh.

Faruque M.O. and Khandoker M.A.M.Y. (2007). Recent advances of goat genotyping in Bangladesh. Pp. 28-40 in Proc. Workshop. Recent Adv. Livest. Genot. Bangladesh, Dhaka, Bangladesh.

Hassan M.R., Talukder M.A.I. and Sultana S. (2010). Evaluation of the production characteristics of the Jamunapari goat and its adaptability to farm conditions in Bangladesh. *Bangladesh Vet.* **27,** 26-35.

Janssens S. and Vandepittte W. (2004). Genetic parameters for body measurements and linear type traits in Belgian bleue de mairie, Suffolk and Texel sheep. *Small Rumin. Res.* **54,** 13-24.

Johnson D.L. and Thompson R. (1995). Restricted maximum likelihood estimation of variance components for univariate animal models using sparse matrix techniques and average information. *J. Dairy Sci.* **78,** 449-456.

Kapell D.N., Ashworth C.J., Walling G.A., Lawrence A.B., Edwards S.A. and Roehe R. (2009). Estimation of genetic associations between reproduction and production traits based on a sire and dam line with common ancestry. *Animal*. **3,** 1354-1362.

Khan M.K.I. and Naznin M. (2013). Study on the live weight and live weight gain of black Bengal and Jamunapari breeds by fitting the linear regression under semi-intensive conditions. *Pakistan J. Biol. Sci.* **16,** 998-1003.

Khan M.K.I. and Khatun M.J. (2013). Different traits of black Bengal goats under two feeding regime and fitting the Gompertz curve for prediction of weaning weight in the semi-scavenging system. *Indian J. Anim. Res.* **47,** 498-503.

Khan (2010). Body Measurements of Goats- Their Genetic Control and Association with Milk Yield. A Report From the Faculty of Veterinary and Animal Science, University of Faisalabad, Faisalabad, Pakistan.

Luo M.F., Wiggans G.R. and Hubbard S.M. (1997). Variance components estimation and multitrait genetic evaluation for type traits of dairy goats. *J. Dairy Sci.* **80,** 594-600.

Mandal A., Roy R. and Rout P. (2008). Direct and maternal effects for body measurements at birth and weaning in Muzaffarnagari sheep of India. *Small Rumin. Res.* **75,** 123-127.

Olechnowicz J. and Sobek Z. (2008). Factors of variation influencing production level, SCC and basic milk composition in dairy goats. *J. Anim. Feed Sci.* **17,** 41-49.

Otuma M.O. and Osakwe I.I. (2008). Estimation of genetic parameters of growth traits in Nigeria Sahelian goats. *J. Anim. Sci.* **2,** 83-86.

Pantelic V., Petrovic M.M., Aleksic S., Ostojic D., Sretenovic L. and Novakovic Z. (2008). Genetic correlations of productive and reproductive traits of Simmental cows in Republic of Serbia. *Arch. Zootech.* **11,** 73-78.

Paul S., Khandoker M.A.M.Y., Moinuddin M.A. and Paul R.C. (2011). Characterization of black Bengal goat. *J. Bangladesh Agric. Univ.* **9,** 61-66.

Paul R.C., Rahman A.N.M.I., Debnath S. and Khandoker M.A.M.Y. (2014). Evaluation of productive and reproductive performance of Black Bengal goat. *Bangladesh J. Anim. Sci.* **43,** 104-111.

Pearson K. (1905). On the General Theory of Skew Correlation and Non Linear Regression. Dulau and Company, London, United Kingdom.

Rahman A.H.M.S. (2007). Morphometric characterization of black Bengal Buck. MS Thesis. Bangladesh Agricultural Univ., Mymensingh, Bangladesh.

Rout P.K., Mandal A., Roy R. and Singh L.B. (1999). Improvement and Conservation of Jamunaparigoats in Their Home Tract. Ministry of Agriculture Report, New Delhi, India.

SAS Institute. (2008). SAS®/STAT Software, Release 8. SAS Institute, Inc., Cary, NC. USA.

Steel R.G.D., Torrie J.H. and Dickey D.A. (1997). Principles and Procedures of Statistics Biometrical Approach. Mc Graw-Hill Co., Inc., London, United Kingdom.

Talukder M.A.I., Hassan M.R., Mohanta U.K. and Amin M.R. (2010). Productive and reproductive performances of brown Bengal goat in hilly area at Naikhongchari. *Proc. Annu. Res. Rev. Work*. **197,** 86-90.