

**STUDIES ON SOME OF THE PHYSICAL,  
HAEMATOLOGICAL AND PRODUCTION  
TRAITS OF BLACK BENGAL GOAT  
UNDER FIELD CONDITION OF  
HILL AND TERAI REGIONS  
OF WEST BENGAL**

*A*  
*Thesis*  
*submitted to the*  
*Bidhan Chandra Krishi Viswavidyalaya*  
*in partial fulfilment of the requirements for the award of the*  
*Degree of Doctor of Philosophy*  
*in*  
**Animal Science**

*By*  
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## Certificate

*This is to certify that the work recorded in the thesis entitled "Studies on some of the Physical, Haematological and Production traits of Black Bengal goat under Field Condition of Hill and Terai Regions of West Bengal" submitted by Sri Shanchal Kanti Biswas for the award of the Degree of Doctor of Philosophy in Animal Science of the Bidhan Chandra Krishi Viswavidyalaya, is the faithful and bonafide research work carried out under my personal supervision and guidance. The results of the investigation reported in the thesis have not so far been submitted for any other Degree or Diploma.*

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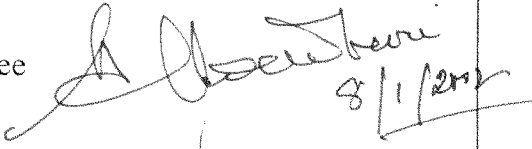
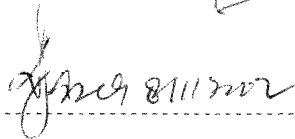
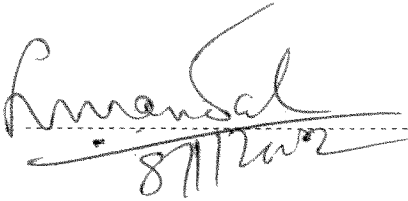
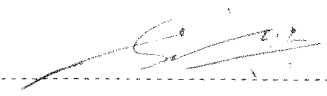
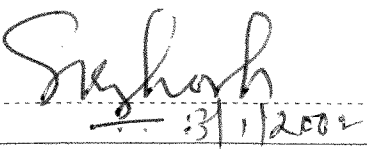
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# List of Abbreviations

adj.	:	Adjusted
Avg	:	Average
B wt	:	Birth weight
BB	:	Black Bengal
BL	:	Body Length
CC	:	Cannon Circumference
cm	:	Centimeter
cmm	:	Cubic millimeter
Co	:	Cobalt
Com	:	Compound
Cu	:	Copper
Cu $\mu$	:	Cubic micron
CV	:	Covariance
DABRTH	:	Days after birth
df	:	Degrees of freedom
DLC	:	Differential Leucocytic Count
Exp	:	Exponential
F	:	Female
Fe	:	Iron
Fig.	:	Figure
g/dl	:	Gram/deciliter
Gro	:	Growth
H	:	Hill
Hb	:	Haemoglobin
HG	:	Heart Girth
JP	:	Jamunapari
kg	:	Kilogram

Lin	:	Linear
LS	:	Least Square
Lt Sz	:	Litter size
M	:	Male
m	:	Million
max	:	Maximum
MCH	:	Mean Corpuscular Haemoglobin
MCHC	:	Mean Corpuscular Haemoglobin Concentration
MCV	:	Mean Corpuscular Volume
mg/ml	:	Milligram/milliliter
min	:	Minimum
Mn	:	Manganese
Ms	:	Monsoon
MS	:	Mean Square
Obs	:	Observation
PCV	:	Packed Cell Volume
PG	:	Paunch Girth
pg	:	Picogram
ppm	:	Parts per million
Pty Kid	:	Parity of kidding
Qua	:	Quadratic
r	:	Pearson Correlation
rpm	:	Rotation per minute
RH	:	Relative Humidity
S	:	Summer
SE	:	Standard Error
Sn Bt	:	Season of Birth
T	:	Terai
TEC	:	Total Erythrocytic Count
Temp	:	Temperature

th : Thousand  
TLC : Total Lecucotyic Count  
W : Winter  
WH : Wither Height  
Zn : Zinc  
30-D wt : Body weight at 30 days  
90-D wt : Body weight at 90 days  
180-D wt : Body weight at 180 days

*Dedicated  
To the  
Memory of  
Late Prasanta Kumar Mondal*

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# CHAPTER-1

# INTRODUCTION

# INTRODUCTION

---

Goat is one of the earliest discovery of mankind in prehistoric times as ready and easy source of meat. The goat is often termed as 'poor man's cow' having diverse ecological adaptability over a wide range of agroclimatic zones. It is preferred over other livestock particularly in droughtprone and tribal areas due to its inherent characteristics of faster multiplicity, smaller size, easy handling, higher digestive and reproductive efficiency, better survival under scarce, minimal biomass and in degenerated environments, better disease tolerance and its substantial contribution in the economy of rural poors, besides meeting their nutritional requirements. Goats require minimal capital investments to be reared and they are highly prolific breeders having very high commercial value and demand of a good price in the market at all the times (Ramdas, 2000).

India has the world's largest goat population, being 120.56 millions (17.22% of the global population) producing 3.13 million metric tons of milk, 0.46 million metric tons of meat and 20 thousand metric tons of skin (FAO, 1998). About 35% of the total meat consumed by Indian people comes from goat (Acharya, 1992). About 15.49% of the goats are slaughtered annually in this country, this percentage has more or less remained steady, however the number of slaughtered animals have shown a marginal increase in the last few years (FAO, 1998). Goats contribute significantly to the national income in the form of chevon, milk and hides, the contribution being Rs. 2,443 crores (3.5% of Agriculture and 10.1% of livestock) [MOA, 1991]. Indian goats are still poor producers and technological ways are to be found out for augmenting their productivity after judicious selection, breeding and improvement of managerial practices.

Out of the 23 well-defined Indian goat breeds (Bhattacharya, 2000), the Bengal Breed especially the Black strain the pride of West Bengal, is considered as a world famous goat breed. The breed is highly preferred since, being small in size it is producing tender, low-fat, very high quality meat and delicate skin (being used for

production of fine leather items). The breed is, however, a poor milk producer (0.4 kg/day). Black Bengal is a very early maturing goat which shows highest ovulation rate (Rao and Bhattacharya, 1980) and also kidding percentage (Bhattacharya, 1982) among all the Indian breeds. Goats in West Bengal contribute 35.7% of the total livestock population (Anon, 1995), the annual growth rate being 1.4% during 1984 to 1989 with the highest density (134/KM<sup>2</sup>) of it being in the state (Anon, 1995). The Black Bengal goats are raised primarily for their superior chevon qualities as well as for their higher prolificacy and fecundity under poor managerial conditions.

The going trends in the preservation of prevailing selected pool of goat genetic resources are getting priority in recent days for the purpose of enhancing productivity. The resultant outcome of crossbreeding of goats has so far been very inconsistent in terms of available literature (Kumar *et al.*, 1983; Singh and Sahni, 1983; Malik *et al.*, 1986; Mia *et al.*, 1993). There now appears to be a growing realization towards the importance of preservation and development (more through selective breeding) of the local breeds because of their adaptation to diversified agroclimatic and socio-economic situations and also better production ability under their natural habitat. With this in view, the breeding strategies and improvement programmes are therefore devised considering the efficiency of production in relation to physical environment, feed and fodder resource availability, management and health aspects. It has been the feeling that the Black Bengal goat, the unique meat producing goat breed to be saved from indiscriminate use of crossbreeding for sustaining its quality meat production under its own habitat.

The state of West Bengal being situated in the eastern part of India presents diverse environments at different agroclimatic zones; and the state has six such variant zones *viz.*, Hill, Terai, Old Alluvial, New Alluvial, Red and Laterite, and Coastal Saline. One zone differs from the other distinctly in relation to environmental temperature, humidity, rainfall, soil and soil fertility, plantations, cropping patterns etc. Animals reared under such variant zones are expected to bear variant impacts on growth, reproduction as well as production. It is said that the reference values in blood chemistry and haematology established in one geographical area for a certain

breed of animals can not be considered as a standard for that breed at all times, at all places and at all statuses (Holman, 1956). Like other livestock, the performances of goat of different zones need to be assessed and compared for prediction of zone specific productivity under field conditions. The present research investigation pertains to the Black Bengal goats under the field conditions at the Terai and Hill zones for comparing and stabilizing various performance parameters, the attempt being of 1<sup>st</sup> kind.

The Terai zone is situated at the northern part of the state which consists of 32 blocks covering Cooch Behar, Jalpaiguri and parts of Uttar Dinajpur and Darjeeling districts (Fig. 1.1). The goats of this region are mostly maintained by extensive grazing or tethering without giving any feed supplementation owing to shattered economic condition of the farmers. Due to nonexistence of adequate grazing land as well as intensive agricultural cropping system, goat rearing is gradually shifted to semi-intensive system with provision of tree leaves weed grasses and kitchen wastes. Cultivation of fodders exclusively for goat rearing is practically nil. Another reason for discouraging goat grazing is the soil erosion caused by goats. Of course, the role of goat in causing ecological degradation and desertification is highly exaggerated basing on misconception. Rather goat acts a seeding machine of trees, especially hard-coated seeds while passing through the animals (Acharya, 1992).

The Hill zone on the other hand, consists of three hill subdivisions of Darjeeling (Fig. 1.2). Goats have the conventional grazing facilities in this zone. Considering the environmental protection, ecological balance and the need of livestock feeding on natural resources in the hills, the concept of land use for intensive fodder production, silvipasture and agro-forestry and efficient recycling of livestock manure for enriching the soil are of particular relevance to hills. The hill environment has certain unique features which differentiates it from that of plains. However, domestication of livestock coupled with excessive grazing over centuries has tended to disturb the ecosystem evolved by nature, drastically. It is, therefore, imperative that if domestic livestock are to co-exist with ideal hill environment, they should be maintained under stall-fed conditions by adopting a land use system which incorporates in itself, intensive fodder production as an important component (Roy, 1995).

The goats in the field level are mostly maintained by grazing without any extra mineral supplementation. Due to heavy rainfall in West Bengal in general and Hill and Terai zones in particular, there is a marked leaching and weathering of soils, making them deficient in plant minerals which is ultimately reflected in the alteration of mineral metabolism in animals and thus affecting productivity due to deficiency disease. It is also accepted through the reports of various workers that the tropical forages can rarely completely satisfy all mineral requirements for animals. Adequate intake of forage by grazing goats is therefore essential in meeting mineral requirements. But factors which greatly reduce forage intake, such as low protein content and increased degree of lignification result in further reduction of total mineral consumed (McDowell *et al.*, 1983). The researchers have not yet established any map of area of mineral content in the state though about 80% of the disease are of nutritional origin (Blood *et al.*, 1983).

In the year 1949, FAO made a recommendation that correcting dietary deficiencies in livestock ration would do much to augment the world supply of meat, milk and eggs. Out of all the essential agents required for the growth of animals, minerals are probably the chief factor and their deficiencies or imbalances in the ration produce specific and nonspecific symptoms by the decrease or even cessation of bodily functions leading to pathological disorders.

In comparison to other ruminants, there is a shortage of information available on production characteristics of goats, particularly in the field level. This may be due to lack of technological innovations to be applicable in farmer's field. The major constraints for increasing their productivity have to be identified and investigated to develop technologies within farmer's resources for the potential improvements of goat production system. At the same time different climatic elements having zone specific impacts on growth, production, reproduction and health status of goat are to be considered.

In view of the above facts, an elaborate research investigation was undertaken for presenting a comparative picture of performances of the Black Bengal goats of Terai and Hill zones in relation to some production, physical measurements and haematoconstituent parameters. The aims of such research venture were to generate

the basic performance information of the precious Black Bengal goats under the field conditions and also to advocate the farmers for taking up need based measures for optimization of goat production at the sound economic level.

The aspects of research studies considered were :

- i) assessment of the production performances of the Black Bengal goats in Terai and Hill zones of West Bengal.
- ii) assessment of physical measurement parameters and prediction of live body weight under field conditions basing on the physical measurements, developing easy equations.
- iii) highlighting of the relationship ( $r$ ) between the live weight and physical measurement parameters.
- iv) estimation of haematoconstituent norms both at cellular and serum levels and their extents of variations due to various effects, the same having effects on the productivities of goats.

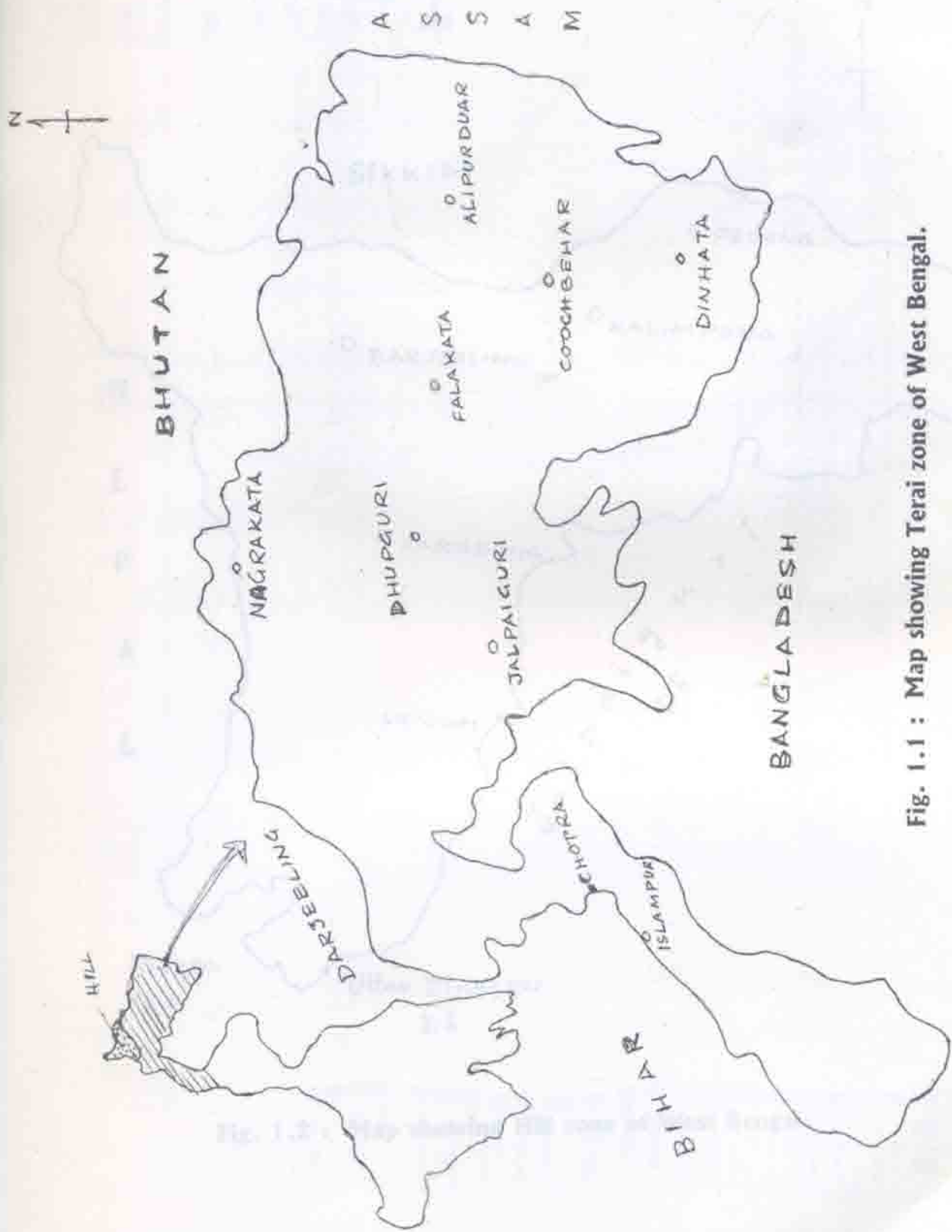


Fig. 1.1 : Map showing Terai zone of West Bengal.

# CHAPTER-2

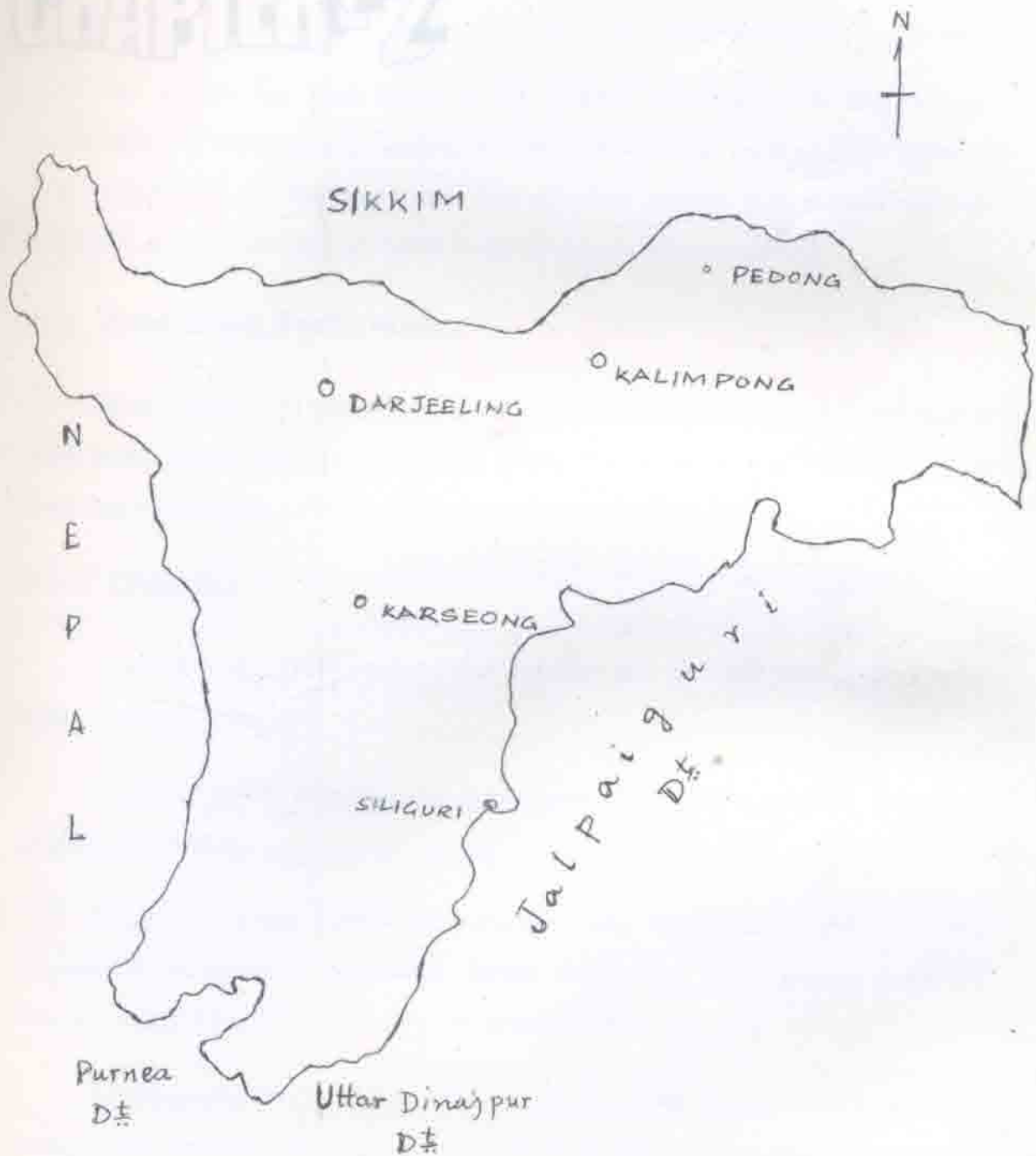


Fig. 1.2 : Map showing Hill zone of West Bengal.

# CHAPTER-2

# REVIEW OF LITERATURE

# REVIEW OF LITERATURE

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An attempt has been made in the present investigation to find out the performances of Black Bengal goats under field condition of Terai and Hill zones of West Bengal. Relevant findings in this field of earlier workers both in farm and field conditions as could be made available in literatures are being reviewed.

## 2.1 Production Performance

A few production parameters having economic importance *viz.*, litter size at birth, birth weight and growth rate of Black Bengal goats were recorded in the identified zones. Some earlier relevant findings are highlighted below.

### 2.1.1 Litter Size

Moulick *et al.* (1966) reported that the litter size of Black Bengal goats under Indian condition to be 2.09.

Ali *et al.* (1973) found twinning percentage of Black Bengal goats under farm condition to be 45%.

Singh and Sengar (1978) observed the breed variations in prolificacy and fecundity in the purebred Jamunapari, Beetal, Barbari and Black Bengal goats, the litter size being 1.15, 1.29, 1.47 and 1.96, respectively.

Verma *et al.* (1991) noted that the overall mean litter size per kidding in Black Bengal goats was 1.26. The effect of breed of sire on litter size was found to be highly significant.

Husain and Islam (1992) assessed the performance potential of Black Bengal goats under small farmers' condition and observed average litter size to be 1.77 increasing from 1.55 at first to 2.02 at fourth parity; the size was not found to differ between seasons.

Alam (1992), after feeding bran supplementation to Black Bengal does before conception, noted the litter size to be 1.8.

Singh and Singh (1999) reported that the Black Bengal goats had significantly higher litter size ( $1.86 \pm 0.12$ ) than Beetal halfbreds (with Black Bengal) [ $1.40 \pm 0.07$ ]. According to the authors, the crossbreeding had adverse effect on prolificacy of Black Bengal goats. They further noted that the litter size increased significantly with the increase in the parity of kidding upto 4<sup>th</sup>, the average litter size being 1.40, 1.71, 1.99 and 2.02 at the 1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup> and 4<sup>th</sup> parity, respectively.

### **2.1.2 Birth Weight**

Bhatnagar *et al.* (1971) reported the average birth weight to be 3.0, 2.8 and 3.5 kg of French Alpine, Beetal and French Alpine x Beetal kids, respectively.

Prasad *et al.* (1971) observed sex to affect the birth weight of Barbari kids, the males being heavier in both singles and multiple births. Season and parity of birth were not observed to have any appreciable effect on the birth weight of kids.

Ali *et al.* (1973) reported the birth weight of Black Bengal kids in Bangladesh Farm to be 1.60 lb.

Singh (1973) studied the factors causing variation in birth weight of Jamunapari kids born in 1966-70. The birth weight of singles averaged 4.92 kg for males and 4.25 kg for females and that of twins averaged 4.44 and 3.96 kg, respectively. Type of birth, sex of kid and the age of the dam had significant effects on birth weight but season of kidding and size had not.

Mittal and Pandey (1974) recorded the birth weight of 50 Barbari and 13 Jamunapari kids to be 2.22 and 3.95 kg, respectively.

Mishra (1976) observed the reproductive performance of goats kept at NDRI. It was reported that the average birth weights of Alpine, Beetal and Alpine x Beetal goats were 3.17, 2.82 and 3.09 kg, respectively.

Ali and Hasnath (1977). in an investigation on Black Bengal goats at Bangladesh Agricultural University observed no appreciable effect of sex on the birth weight of kids.

Singh *et al.* (1977), in a study with birth weight of different purebred and crossbred goats (in various combinations), observed appreciable effects of breed, sex, litter size and season on birth weight. Highest birth weight was recorded in Jamunapari x Saanen kids to be  $3.063 \pm 0.107$  kg. In all the groups of kids born, males were heavier than females, the average birth weight of kids born as single was higher than those born as twins; summer as kidding season was inferior to winter and rainy season in respect to birth weight.

Mukundan and Bhat (1978) at NDRI studied the birth weight of Malabari, Malabari x Saanen and Malabari x Alpine kids and obtained the birth weight to be 1.8, 2.9 and 1.9 kg for single and 1.7, 2.2 and 1.9 kg for twins, the litter size effect being appreciable in case of Malabari x Saanen crosses.

Khan *et al.* (1979) obtained the average birth weight of 83 Jamunapari kids as 3.04 kg and the birth weight was observed to be affected significantly by season and type of birth. However, year of birth or sex had no appreciable effect to cause any variation of the trait.

Ali (1980) studied the relation of birth weight of kids to their post-natal growth in Black Bengal goats and found the birth weight of 77 male and 99 female kids to average 1.80 and 1.75 lb, respectively.

Sarma *et al.* (1981) in a study observed the average birth weight of 136 Assam Hill kids to be 1.17 kg. They also observed that the type of birth (single vs multiple) had a significant effect on birth weight.

Acharya (1982) reported birth weight of Black Bengal goats to be 1.3 kg.

Khan and Sahni (1983) recorded birth weight of Jamunapari kids as  $2.840 \pm 0.041$  kg. Sex, type and weight of dam at kidding significantly affected body weight at birth. Male kids were heavier than the females. Kids born as single weighed 12% more than the twins at birth.

Kumar and Singh (1983) recorded the birth weight of Barbari, Black Bengal and Jamunapari x Black Bengal crosses as  $1.80 \pm 0.081$ ,  $1.21 \pm 0.07$  and  $1.32 \pm 0.037$  kg, respectively.

Sinha and Sahni (1983) observed the birth weight to average  $2.97 \pm 0.13$ ,  $2.76 \pm 0.51$ ,  $1.84 \pm 0.22$  and  $0.98 \pm 0.10$  kg in Jamunapari, Beetal, Barbari and Black Bengal kids, respectively. Highly significant effect of season of kidding ( $P < 0.01$ ), type of birth ( $P < 0.01$ ) and sex ( $P < 0.01$ ) on birth weight were observed. Summer born kids were heavier than winter born, single born kids of either sex were heavier than twins/triplets and males were always heavier than females.

Pattanaik and Mishra (1985) recorded the birth weight of Bengal goat under field condition of Orissa to be  $1.20 \pm 0.04$  kg.

Malik *et al.* (1986) worked out LS-means with SE of birth weight of Beetal and Black Bengal goats and revealed that Beetal goats had a higher birth weight ( $2.20 \pm 0.04$  kg) than Black Bengal ( $1.13 \pm 0.04$  kg). Year of kidding also affected weight at birth. Kids born as single averaged 2.10 kg body weight at birth vs 1.76 and 1.35 kg for those born as twins and triplets, respectively ( $P < 0.05$ ).

Dron (1987) observed the birth weight of Black Bengal goat at Ranchi as  $1.24 \pm 0.02$  kg.

Mishra (1987) noted the birth weight of Black Bengal goats as  $1.50 \pm 0.20$  and  $1.33 \pm 0.04$  kg for male and female, respectively.

Patro and Mishra (1987) recorded birth weight of Ganjam goat reared in villages of Southern Orissa and found it to be  $2.45 \pm 0.07$  kg.

Patnaik and Nayak (1988) obtained the birth weight of Black Bengal goats as  $1.50 \pm 0.14$  and  $1.62 \pm 0.09$  kg for single birth and  $1.16 \pm 0.30$  and  $1.50 \pm 0.20$  for twin birth for male and female, respectively. The litter size and sex effect is appreciable, female being heavier than males.

Gupta *et al.* (1989) recorded higher weight of 1.13 kg for male kids over 1.04 kg for females of Black Bengal goats at Haringhata Farm.

Singh *et al.* (1991) studied the body weights at birth in Black Bengal and its crosses with Jamunapari and Beetal. The overall birth weight was noted to be  $1.64 \pm$

0.02 kg which was significantly influenced by genetic group, sex, season of birth and type of birth. Beetal x Black Bengal kids were significantly heavier ( $1.93 \pm 0.04$  kg) at birth than purebred Black Bengal ( $1.24 \pm 0.02$  kg) and JP x BB ( $1.75 \pm 0.02$  kg) kids.

Acharya (1992) noted the birth weight of White, Brown and Black types of Bengal goats to be 1.12, 1.09 and 0.90 kg, respectively.

Chatterjee (1992) observed the birth weight of Black Bengal kids to be  $1.398 \pm 0.012$  and  $1.271 \pm 0.012$  kg in males and females, respectively, the influence of sex being highly significant.

Das *et al.* (1992) noted in Assam goats that the male kids to be heavier at birth than females and the mean birth weight decreased progressively with the litter size.

Islam and Rahman (1992) analysed the factors affecting the birth weight of 500 Bengal kids and reported that the litter size, sex of kid and season had significant effects. For male and female kids born in summer, birth weight averaged  $971.9 \pm 7.9$  and  $925.0 \pm 7.6$  g, respectively.

Husain and Islam (1992) reported the birth weight of Black Bengal kids in small farmers' condition of Bangladesh as  $0.970 \pm 0.019$  kg. The birth weight was observed to be increased with increased parity of kidding while it was decreased significantly with increase in litter size at birth.

Das *et al.* (1993) observed in Assam Hill goats and their crosses having 50% and 75% Beetal inheritance, birth weight averaged  $1.12 \pm 0.06$ ,  $1.16 \pm 0.06$  and  $1.16 \pm 0.06$  kg, respectively, and male kids showed higher birth weight compared to females.

Mia *et al.* (1993) observed the birth weight of Black Bengal, Barbari, Anglo-Nubian and Barbari x Black Bengal kids as  $1.35 \pm 0.03$ ,  $2.22 \pm 0.09$ ,  $3.16 \pm 0.09$  and  $1.64 \pm 0.05$  kg, respectively and concluded that genetic groups had highly significant effect on body weight at birth.

Mahapatra and Nayak (1996) in Orissa Farm reported that the crossbred Black Bengal goats with Ganjam produced kids with average birth weight of  $2.15 \pm 0.07$  kg.

Husain *et al.* (1997) observed that birth weight of Black Bengal kids in 3 locations of Bangladesh were almost similar (1.01 kg) with significantly lower birth weight in 4<sup>th</sup> location (0.88 kg). Effect of birth type and sex were significant with higher weights for single (1.03 kg) vs. twin (0.98 kg) vs. triplet (0.92 kg) and male kids (1.03 kg) vs. female (0.93 kg).

Singh and Singh (1998) observed significant ( $P < 0.05$ ) difference in birth weight of Jamunapari x Black Bengal kids due to sex, males being heavier than females.

Das and Roy (1999) observed in Bengal goats that the male kids at birth were heavier than females in all the seasons and types of birth, but the difference was not statistically significant. Seasons had highly significant ( $P < 0.01$ ) effect on overall birth weight of kids and single born kid showed significantly ( $P < 0.05$ ) higher birth weight than twin.

Singh (1999) noted significant variation ( $P < 0.01$ ) of birth weight due to genetic group, sex, season of birth and type of birth.

### 2.1.3 Growth

Masud (1964) assessed the live weight of Black Bengal goats under field condition and observed that the average live weight of small adult males and females to be 13 kg and 9 kg, respectively.

Guha *et al.* (1968) studied on growth rates in Black Bengal goats of Haringhata Farm, in relation to body weight at birth, 16<sup>th</sup> week, 36<sup>th</sup> week and 52<sup>nd</sup> weeks of age. The result of body weight are presented below :

Sex	Birth weight	16 <sup>th</sup> week	36 <sup>th</sup> week	52 <sup>nd</sup> week
Female	2.56 lb	12.38 lb	17.36 lb	24.62 lb
Male	2.90 lb	14.37 lb	21.64 lb	28.66 lb

Correlation between body weight at different stages of growth in overall males and females when taken together were found significantly positive. Litter size at birth had no influence on the growth characters at different stages except birth weight of male kids. Sex and season of birth, on the other hand influenced all the growth characters upto 52 weeks of age.

Ali *et al.* (1973) reported weaning weight and adult weight of Black Bengal goats under farm condition to be 19.5 lb and 23.0 lb, respectively.

Hafez (1974) observed that the sex difference of the growth characters was pronounced and it might be due to early secretion of sex hormones by gonads of male kids. Under the influence of androgen having anabolic effect, the male kids were capable of growing at faster rate during post-natal development.

Singh and Singh (1974) reported that growth rate of Jamunapari kids was highest between birth and 4 months of age and significantly lower between 4 and 8 months. It increased again between 8 and 12 months. The growth of males was significantly better than that of females, except between 4 and 8 months, when there was no sex differences. Type of birth was also observed to have non-significant effect on growth.

Singh and Sengar (1978) in UP Farm observed the breed variation in the body weights at subsequent intervals of purebred Jamunapari, Beetal, Barbari and Black Bengal goats, the body weight being highest in Beetal and lowest in Black Bengal at any given age.

Mittal and Pandey (1978) observed the growth rate from birth to 9 months of age at monthly interval in Barbari kids. They found that there was no significant effect of sex on birth weight and live weight of single and twin kids at any age interval. Male kids were heavier than female kids at any interval from 1 month to 9 month but statistically non-significant.

Ali (1979) studied the growth pattern of 98 Black Bengal goats under farm condition of Bangladesh and observed the weight gain being maintained regularly from birth to 1 year of age and after that the growth pattern was in a zig-zag way

instead of in a straight line. This might be due to solar radiation in association with humidity and rainfall along with other factors like parasitism, management, pregnancy, lactation etc.

Ali (1980) observed that the average birth weights of Black Bengal kids to be 1.80 lb and 1.75 lb in the males and females with only 9.48 lb gain in growth at the age of 13 weeks of both the sexes.

Khan and Bhat (1981) studied the growth rate of different breeds of Indian goat presented in a tabular form as below :

Breed	Sex	Stages of growth (kg)			
		At birth	Weaning	6 months	12 months
Black Bengal	M	1.1	4.8	6.7	11.8
	F	1.0	4.3	6.0	8.1
Assam Hill	M	0.9	2.2	-	-
	F	0.9	2.3	-	-
Jamunapari	M	3.6	11.5	16.7	22.9 *
	F	2.9	10.4	12.2	19.2
Malabari	M	1.9	5.4	8.5	18.2
	F	1.7	5.5	7.8	11.3
BB x JP	M	1.32	-	9.96	-
	F	-	-	-	-

Sarma *et al.* (1981) studied the growth pattern of Assam local goats which varied significantly due to type of birth or litter size. Kids born as singles had higher body weight than twins and triplets, and the kids with higher birth weight continued to be heavier at later stages of growth. The season of birth, however, had non-significant effect on body weight at birth and at 45<sup>th</sup> and 180<sup>th</sup> days of age but had significant influence at 90<sup>th</sup> and 135<sup>th</sup> days of age. The body weight gain per day were recorded to be 35g, 28 g and 32g in singles, twins and triplets, respectively.

Singh *et al.* (1981) studied certain baseline information of 43 deshi does from a local farmer at Makhdoom under zero input system. The authors' observations on body weight (kg) be stated in the tabular form as below :

Sex	Birth weight	1 month	3 month	6 month	9 month	12 month
Male	3.51 ± 0.11	6.64 ± 0.27	9.19 ± 0.54	13.52 ± 1.76	18.35 ± 1.09	23.1 ± 1.71
Female	3.44 ± 0.13	6.22 ± 0.21	8.63 ± 0.29	13.47 ± 0.38	17.92 ± 0.76	18.21 ± 0.47

Sarma *et al.* (1982) studied the performance of Assam local goats and observed that these goats gained approximately 29.38 g per day from 5 to 12 months of age.

Khan and Sahni (1983), in an experiment conducted on Jamunapari goats, opined that the type of birth, season of birth and weight of dam had significant effects on the body weight of kids. The mean body weight at birth, 1, 2 and 3 months of age were found to be  $2.840 \pm 0.041$ ,  $6.142 \pm 0.086$ ,  $8.651 \pm 0.091$  and  $10.680 \pm 0.103$  kg, respectively.

Kumar and Singh (1983) studied the performance of different goat breeds in respect to body weight gain. The body weight of Black Bengal and its halfbred with Jamunapari (in kg) at birth, 1<sup>st</sup> month, 4<sup>th</sup> month and 6<sup>th</sup> month were  $1.21 \pm 0.07$  vs  $1.32 \pm 0.037$ ,  $2.74 \pm 0.116$  vs.  $3.07 \pm 0.120$ ,  $5.76 \pm 0.255$  vs  $6.84 \pm 0.302$  and  $7.82 \pm 0.382$  vs.  $9.96 \pm 0.419$ , respectively. The daily weight gain of Black Bengal kids during birth – 1 month, 1 – 4 months and 4 – 6 months period were  $51.0 \pm 6.89$ ,  $39.2 \pm 5.39$  and  $36.8 \pm 3.51$  g, respectively.

Pattanaik and Mishra (1985) recorded the performance of Black Bengal goats under field condition of Orissa. The body weights at birth, 3 months, 6 months and 9 months of age were  $1.20 \pm 0.04$ ,  $4.80 \pm 0.09$ ,  $7.50 \pm 0.18$  and  $9.70 \pm 0.11$  kg, respectively. The live weights were observed to be increased significantly ( $P < 0.01$ ) with the increase of age.

Malik *et al.* (1986), in a study with Black Bengal, Beetal and their crosses observed the genetic group to affect significantly ( $P < 0.01$ ) the body weight at birth

and at monthly intervals upto weaning (90 days) as well as the daily preweaning gain ( $P < 0.01$ ). Type of birth had also significant effect on the body weight at birth and upto weaning. The kid as a single had a higher mean birth weight (2.10 kg) than those individual kids born either as twins (1.76 kg) or as triplets (1.35 kg). The daily weight gain was also higher for single kids (59.82 g/day) than either for twins (50.52 g/day) or for triplets (41.28 g/day).

Dron (1987) noted different body weights at 3, 6, 9 and 12 months in Black Bengal goats as  $5.65 \pm 0.10$ ,  $8.97 \pm 0.14$ ,  $11.79 \pm 0.19$  and  $14.05 \pm 0.29$  kg, respectively.

Pander *et al.* (1987) recorded weaning weight, 6 months weight and 12 months weight and daily gain in Beetal, Black Bengal and their reciprocal crosses to be  $9.28 \pm 0.46$  kg,  $11.78 \pm 0.40$  kg,  $17.01 \pm 2.46$  kg and  $28.91 \pm 1.53$  kg, respectively.

Patro and Mishra (1987) made some observation on Ganjam breed of goat and found the live weight (kg) and daily weight gain (g) at birth, 3 and 6 months to be  $2.45 \pm 0.07$  and 0,  $7.11 \pm 0.13$  and  $51.77$ ; and  $9.79 \pm 0.21$  and  $29.77$ , respectively. There was an increase in live weight accompanied by a decrease in the live weight gain with an increase in age ( $P < 0.01$ ).

Mishra (1987) reported the body weight of Black Bengal goats at 3, 6, 9 and 12 months of age as  $6.21 \pm 0.42$  &  $4.94 \pm 0.31$ ,  $8.15 \pm 0.26$  &  $7.56 \pm 0.26$ ,  $9.73 \pm 0$  &  $8.19 \pm 0.41$  and  $10.0 \pm 0$  &  $9.95 \pm 0$  kg for male and female, respectively.

Patnaik and Nayak (1988) noted the body weight of Black Bengal, Ganjam and Jamunapari breeds. The average weight in Black Bengal goats at 3 months and 1 yr of age were  $6.08 \pm 1.04$  &  $5.71 \pm 0.31$  kg and  $9.80 \pm 0.83$  &  $9.04 \pm 0.08$  kg for the males and females, respectively.

Gupta *et al.* (1989) noted that the body weight of male and female Black Bengal kids at 16 weeks of age were 5.48 and 5.17 kg, respectively. Body weight at 16<sup>th</sup> weeks of age was influenced by sire's birth weight or body weight. The growth rate of kids, but not their birth weight, differed among sires.

Singh *et al.* (1991) reported that the body weight at weaning (3 months of age) of the Black Bengal goats averaged  $6.88 \pm 0.08$  kg and the weight was affected by genetic group, sex, season of birth, type of birth. Beetal x Black Bengal kids were significantly heavier at birth and at 3 months of age than the purebred Black Bengal and Jamunapari x Black Bengal kids.

Chatterjee (1992) recorded the body weight of Black Bengal goats at birth, 3 months and 6 months of age to be  $1.398 \pm 0.012$  vs  $1.271 \pm 0.012$  kg,  $4.744 \pm 0.042$  vs  $4.433 \pm 0.040$  kg and  $6.731 \pm 0.023$  vs  $6.040 \pm 0.032$  kg in the males and females, respectively, the sex effect being highly significant.

Husain and Islam (1992) assessed the production potential of Black Bengal goats under field condition and body weight at 6 months of age were observed to be  $8.85 \pm 0.73$  and  $7.84 \pm 0.77$  kg with daily gain of 42.89 and 38.39 g in the male and female kids, respectively.

Das *et al.* (1993) found the body weight at birth and at 3 months of age to be higher in males as compared to females, the sex effect being significant.

Mia *et al.* (1993) obtained the body weight at birth, 3 months and 6 months in four different breeds of goats which were as below :

Parameters	Black Bengal	Barbari	Anglo-Nubian	Barbari x Black Bengal
Birth weight	$1.35 \pm 0.03$	$2.22 \pm 0.09$	$3.16 \pm 0.09$	$1.64 \pm 0.05$
Weight at 3 months	$5.22 \pm 0.32$	$7.52 \pm 0.31$	$12.09 \pm 0.49$	$6.93 \pm 0.32$
Weight at 6 months	$7.69 \pm 0.46$	$11.50 \pm 0.37$	$18.95 \pm 0.57$	$10.59 \pm 0.62$

The body weight at birth and at each stage of growth of kids were highly significant ( $P < 0.01$ ) due to genetic groups. The performance of Black Bengal halfbreds were very close to Barbari in meat production potential and it was opined that introduction of Barbari genes be helpful for combining of meat yield genes of Black Bengal goats.

Mahapatra and Nayak (1996) obtained the body weight of the halfbred Black Bengal with Ganjam goats at birth and at 180 days of age to be  $2.15 \pm 0.07$  and  $11.39 \pm 0.85$  kg, respectively, Ganjam genes combining better with Black Bengal genes for higher meat production.

Husain *et al.* (1997) studied growth performance of Black Bengal kids in 4 different locations of Bangladesh and observed that monthly weight gain of kids in 1<sup>st</sup> 3 locations were similar with significantly lower weight gain for region 4. Birth type and sex effected monthly weights in different regions where single and male kids had significantly higher weights for all the regions. According to the authors, the wide location variation in daily weight gain (38.212 g to 51.912 g) was due to variations in adequate feed availability, management and stressful environmental conditions throughout the year.

Singh (1998) observed significant yearly weight variations in Black Bengal, Beetal and Jamunapari goats due to breed, litter size and sex but not season. Single born kids were significantly heavier than the multiples, indicating negative relationship between the litter size and weight gain. However, variation in body weight was found to be non-significant due to season of birth.

Singh and Singh (1998) recorded live body weight of Jamunapari x Black Bengal kids at 6, 9 and 12 month of age as 10.48, 11.97 and 14.16 kg, respectively and daily weight gain from birth to 3 months and from 3 months to 6 months of age as 61.17 and 32.42 g. Type of birth, season of birth and body weight of dam had a significant effect on all these weights and on daily gain from birth to 3 months of age and daily gain from 3 to 6 months was significantly affected by season of birth and dam's body weight at kidding.

Singh and Singh (1998) undertook the performance studies of Black Bengal and its crosses with Beetal under village conditions. The overall mean body weights at birth and at 1, 2, 3, 4, 5 and 6 months of age in Black Bengal goats were 1.632, 3.181, 4.009, 5.730, 6.291, 7.532 and 8.522 kg, respectively. Crossbred kids were heavier than purebred kids at 1, 2 and 4 – 6 months of age ( $P < 0.01$ ). Sex had

significant effect on all the growth/production traits. Males were heavier than females at all ages but the difference were not significant at birth and 3 months of age. Single born kids were heavier than twins and triplets at all ages. Season of birth did not have any appreciable effect on birth weight and subsequent body weights upto 6 months as studied.

Majid *et al.* (1999) recorded body weight of Black Bengal goats at 6 – 12, 12 – 18 and 18 – 24 months of age as  $12.29 \pm 0.76$ ,  $16.28 \pm 0.70$  and  $18.43 \pm 0.84$  kg for males and  $14.90 \pm 0.64$ ,  $19.98 \pm 0.58$  and  $18.73 \pm 0.70$  kg for females, respectively. Body weight was affected ( $P < 0.01$ ) by age but sex had no significant effect.

## 2.2 Physical Measurement Traits

Mukherjee *et al.* (1979) observed the phenotypic parameters in Grey and Brown varieties of Bengal goats as follows :

Age group	Breed	Length (cm)	Height (cm)	Chest girth (cm)
0 – 3 months	Grey	$30.4 \pm 0.91$	$35.6 \pm 0.94$	$38.6 \pm 1.16$
	Brown	$29.1 \pm 0.89$	$34.7 \pm 0.87$	$36.5 \pm 0.96$
3 – 6 months	Grey	$40.2 \pm 0.83$	$45.8 \pm 0.82$	$50.4 \pm 0.79$
	Brown	$40.8 \pm 0.73$	$47.2 \pm 0.67$	$50.8 \pm 0.79$

Singh *et al.* (1979) recorded the different body measurements of Black Bengal goats at Agra Farm as under :

Body parameters	Milch teeth	Permanent incisors			
		1 <sup>st</sup> pair	2 <sup>nd</sup> pair	3 <sup>rd</sup> pair	4 <sup>th</sup> pair
Length (cm)	$43.7 \pm 0.70$	$48.0 \pm 0.44$	$48.6 \pm 0.37$	$50.7 \pm 0.67$	$54.2 \pm 1.77$
Height (cm)	$49.1 \pm 0.84$	$54.3 \pm 0.47$	$55.1 \pm 0.50$	$56.0 \pm 0.92$	$58.0 \pm 1.77$
Chest girth (cm)	$53.3 \pm 0.76$	$58.8 \pm 0.41$	$60.2 \pm 0.29$	$62.6 \pm 0.91$	$64.7 \pm 1.25$
Paunch girth (cm)	$58.5 \pm 0.82$	$64.1 \pm 0.64$	$66.4 \pm 0.52$	$69.1 \pm 1.17$	$73.8 \pm 2.12$

Correlation of body weight was observed to be highest with paunch girth and chest girth.

Khan and Sahni (1983) recorded differed body measurements in Jamunapari kids, raised under farm condition. Type of birth and weight of dam were noted to have significant effect on linear body measurements of kids at all ages. The effect of sex was significant on heart girth and paunch girth at birth, paunch girth at one month, and height and paunch girth at weaning. Season of birth affected significantly body length, height, heart girth and paunch girth at two months; and body length, height and paunch girth at weaning.

Kumar and Singh (1983) observed the body length, wither height, chest girth and paunch girth of pure Black Bengal and halfbred Jamunapari with Black Bengal goats at 6 months of age to be  $42.31 \pm 0.754$  cm and  $46.08 \pm 0.655$  cm;  $43.52 \pm 0.721$  cm; and  $47.54 \pm 0.641$  cm;  $44.41 \pm 0.783$  cm and  $48.21 \pm 0.632$  cm; and  $48.96 \pm 0.791$  cm and  $50.99 \pm 0.681$  cm, respectively. Developing regression equations, body weight could be predicted at 6 months of age on the chest girth (76.1%) followed by body length (74.18%) and height (69.10%) in the Black Bengal kids while in halfbreds the corresponding values were 66.7, 58.39 and 56.06% with body length, height and chest girth, respectively.

Majumdar and Majumdar (1983) reported the body length, wither height and chest circumference of the adult male and female Chegu goats to be 92 – 119 and 71 – 104 cm, 51 – 78 cm and 45 – 70 cm and 71 – 107 and 59 – 86 cm, respectively.

Bhattacharya *et al.* (1984) recorded the chest circumference, wither height and body length of adult Black Bengal goats as  $55.24 \pm 0.72$ ,  $46.53 \pm 0.57$  and  $46.15 \pm 0.68$  cm, respectively.

Sarma *et al.* (1984) recorded different body measurements at different ages of Assam local x Beetal kids to be as below :

Parameters	Average Estimates (cm) at			
	Birth	30 <sup>th</sup> day	60 <sup>th</sup> day	90 <sup>th</sup> day
Body length	$26.76 \pm 0.44$	$34.26 \pm 0.38$	$38.27 \pm 0.42$	$41.04 \pm 0.42$
Height at wither	$28.10 \pm 0.38$	$36.84 \pm 0.38$	$38.55 \pm 0.40$	$40.73 \pm 0.39$
Heart girth	$28.53 \pm 0.38$	$35.09 \pm 0.34$	$39.44 \pm 0.42$	$41.60 \pm 0.41$

Pattanaik and Mishra (1985), in Orissa obtained the body length, height at wither and heart girth of Black Bengal goats at 6 months of age to be  $42.12 \pm 0.44$ ,  $47.56 \pm 0.38$  and  $48.31 \pm 0.46$  cm, respectively.

Patro and Mishra (1987) noted different body measurements of Ganjam goats reared in villages of Orissa and found that the body length (oblique), height at wither and heart girth were  $48.90 \pm 0.44$ ,  $54.66 \pm 0.41$  and  $50.30 \pm 0.39$  cm, respectively at 6 months of age. Significant ( $P < 0.01$ ) increase in all the body measurements along with age were observed.

Singh *et al.* (1987) measured the different body measurements in the Black Bengal goats at one year of age and observed significant ( $P < 0.01$ ) correlations ( $r > 0.6$ ) of body length, heart girth and paunch girth with live weight.

Chatterjee (1992) recorded different body measurements of Black Bengal goats at 6 month of age as under :

Parameters	Male	Female
Body length (cm)	$31.48 \pm 0.13$	$35.85 \pm 0.12$
Heart girth (cm)	$49.42 \pm 0.23$	$43.15 \pm 0.18$
Height at wither (cm)	$44.83 \pm 0.15$	$40.04 \pm 0.14$

Khan *et al.* (1992) studied different body measurements in 300 Bengal goats and these were found to be 46.52 cm vs 48.33 cm for body length, 52.73 cm vs 54.03 cm for heart girth, 68.06 cm vs 70.65 cm for skin length at 10.08 months and 15.08 months of age for males and females, respectively, all difference between the sexes being significantly correlated with age, body length and heart girth.

Das *et al.* (1993) reported that body length, height at wither and heart girth at birth and at 3 months of age were higher in males than that of females in both the Assam Hill goats and their crosses with Beetal. The heritabilities of the linear body measurements were estimated to be moderate to high.

Mahapatra and Nayak (1996) correlated the body weight with different physical measurements in the Black Bengal – Ganjam crossbred goats at birth, 30 day, 60 day, 90 day, 120 day, 150 day and 180 day of age. The height at wither was observed to be correlated with body weight at all the ages except at birth. Other characters, viz., body length, wither height, chest girth and cannon circumference did not show any appreciable trend of correlation at any age of life studied.

Varada *et al.* (1997) studied different body measurements of local goats under field condition and observed that the body weight to be positively ( $P < 0.01$ ) correlated with heart girth and body length. The  $R^2$  value indicated that the body weight of doe could be predicted from heart girth with at least 73% reliability. A multiple regression equation including heart girth, abdominal girth and body length was reported with non-significant regression coefficients and low predictability. A regression equation  $Y = 49.91 + (1.04 \times \text{heart girth})$  could be set for predicting body weight under field condition on the basis of heart girth.

Singh (1998) noted on yearling pure Black Bengal and Black Bengal halfbreds (involving Jamunapari and Beetal) the sex to have significant effect ( $P < 0.01$ ) on body length, height at wither, heart girth as well as on the paunch girth. The effect of genetic group was also observed to be significant on the body measurements except heart girth, the season of birth was observed to affect significantly the body length ( $P < 0.01$ ) and paunch girth ( $P < 0.05$ ).

Majid *et al.* (1999) observed positive correlation ( $P < 0.01$ ) between body weight and body measurements and concluded the hip height, chest girth, and head length to be used to estimate body weight under field condition.

Singh (1999), while studying on the Black Bengal and Black Bengal halfbreds (with Jamunapari and Beetal) kids, found the body biometrics to vary significantly ( $P < 0.01$ ) due to genetic group and type of birth (or litter size). The sex of kids was also found to affect the body biometrics significantly except paunch girth, while the season of birth had significant effect on body length and heart girth. The phenotypic and genetic correlations of birth weight with body measurement, were positive and moderately high in magnitude.

Amin *et al.* (2000) observed that height at wither was significantly higher in Jamunapari x Black Bengal (JBB) than in Black Bengal selected for growth (SBB) and suggested that selection for rapid growth rate within Black Bengal goat increased its live weight and improved meat production.

Singh *et al.* (2000), from a study concluded that body weight of Black Bengal goats could be predicted on the basis of body length, height at wither, heart girth, paunch girth with 93.41, 90.38, 95.18, 93.36 accuracy, respectively. The combination of more than one variate in an equation resulted only 1.41% improvement in accuracy as compared to a single variate equation.

### **2.3 Haematological Parameters**

Literature on the blood constituents studies are limited. The information as could be made available are being reviewed.

Wintrobe (1933) had undertaken extensive studies on goats blood and reported the TEC of blood to be  $17.33 \times 10^6/\text{cmm}$ .

Validixia and Othensmeyer (1963) reported a rapid increase of Hb(%), T. C and PCV when exposed to high altitude followed by a slow haemostasis.

Holman and Dew (1965) observed a common pattern between PCV and Hb concentration in goats, which showed three phases. At first a fall during first month, then a rise to the 3<sup>rd</sup> month and again a fall to the mature level at 30 months. A multiple regression of Hb, PCV, and MCHC was also reported to be high.

Bhalia and Sharma (1966) estimated the TEC of healthy hilly goats to be  $16.6 \times 10^6/\text{cmm}$  as estimated.

Gill and Mishra (1972) studied some of the blood constituent characters of the female Beetal goats of different ages. The average values were reported to be higher in animals of young age groups. TEC reported, was  $11.40 \times 10^6/\text{cmm}$ .

Dey Sarkar (1974) recorded total erythrocyte count (TEC) of goat to be highest among other domestic animals, whereas the PCV as lowest. He also identified

that there was no erythrocyte sedimentation during the first 24 hours and Rouleaux formation was absent.

Patra (1981) estimated some haematological values of goat's blood as under :

TEC ( $10^6/\text{cmm}$ ) :  $11.32 \pm 0.41$ , PCV (%) :  $26.9 \pm 0.97$ ; MCV ( $\text{Cu}\mu$ ) :  $23.8 \pm 0.5$ , Hb (g/dl) :  $10.71 \pm 0.30$ , MCHC (%) :  $(40.27 \pm 0.87$  and MCH (pg) :  $9.55 \pm 0.24$ .

Majumdar *et al.* (1982) in a survey of 332 healthy Indian Pashmina goats found that the age did not have any significant effect on Hb content.

Pyne *et al.* (1982) estimated some of the blood constituent traits of the Black Bengal goats of alluvial zones, the means of the traits being as :

TEC  $12.35 \pm 0.35$  m/cmm, TLC :  $10.18 \pm 0.24$  th/cmm; Hb :  $9.98 \pm 0.56$  g/dl, Neutrophils :  $34.61 \pm 0.65$  per cent, Lymphocytes  $60.25 \pm 0.14$  per cent, Monocytes  $3.06 \pm 0.16$  per cent, Eosinophils :  $2.04 \pm 0.14$  per cent and Basophils :  $0.04 \pm 0.02$  per cent.

Okorie and Anugwa (1986) reported the mean Hb content in 36 Kano Brown goats over 12 weeks of age to be 12.04 g/dl.

Popisil *et al.* (1987) estimated mean Hb value in 165 Cameroon goats to be 113.4 g/litre. The effect of age on Hb content was not found to be significant.

Rastogi and Singh (1990) reported the Hb content of Mountain Gaddi goats to range from 10 – 12 g/dl with an average  $11.1 \pm 0.72$  g/dl.

Siddiqua *et al.* (1990) in a survey of 64 Black Bengal goats in the age group of one year to two years found that the mean Hb value to be 11 g/dl of blood.

Haba *et al.* (1991) observed in 12 adult Granadina goats and their 15 female progenies during the first 30 post natal weeks, the Hb concentration was lower than the adults.

Das *et al.* (1992) estimated the haematological profiles during the pre and post weaning age of Assam Hill kids. The levels of TEC, Hb, PCV and MCV values decreased significantly ( $P < 0.01$ ) during post weaning period in comparison to pre-weaning period, the MCHC, of course, showed the trend of increase at the post-

weaning period. The authors obtained higher haematological values in the male kids than in the female kids, the sex effect being highly significant ( $P < 0.01$ ).

Pan and Maitra (1992) observed the effect of tannin and tannic acid on haematological profiles of Black Bengal goats. Salseed tannin treatment resulted in the highest value for PCV, Hb concentration, MCHC and TLC in the goats while tannic acid resulted in the highest value for total erythrocytes.

Ghosh *et al.* (1993) did not find any significant variation in the haematological values of goats reared under the free range and deep litter systems in the New Alluvial Zone.

Mondal (1995) reported that the mean Hb values of the Black Bengal kids and adult goats to be  $8.82 \pm 0.12$  g/dl and  $8.61 \pm 0.12$  g/dl in Terai zone while the values were  $9.24 \pm 0.13$  g/dl and  $9.13 \pm 0.14$  g/dl, respectively in Hill zone, the zone-effect being significant ( $P < 0.01$ ) on the variations of the Hb content.

Das *et al.* (1997) reported that the mean value of Hb to differ significantly ( $P < 0.01$ ) between the physiological stages of goats-kids and adult, the Hb% being higher in kids due to higher TEC. The mean Hb value was found to be higher in the goats of Red and Laterite zone than in the New Alluvial zone, the variation due to zone-effect being highly significant ( $P < 0.01$ ).

Howladar and Huq (1997) observed the effect of experimentally induced fasciolosis on haematological profiles of Black Bengal goats in Bangladesh. The Hb content and the PCV of the non-infected controlled group were 10.51 g/dl and 32.21%, respectively, the values of both the estimates being lower in the Fasciola-infected group. Age and season did not cause any appreciable variation in both the Hb and PCV values.

## **2.4 Serum Trace Minerals**

### **2.4.1 Iron (Fe)**

Wanner and Boss (1978) reported the serum iron values at 30 days, 7<sup>th</sup> week and at 77 days to be 77, 232 and 180  $\mu\text{g/dl}$ , respectively in the exotic goats. The

authors also noticed that the serum iron was highest at 5 weeks but there was insignificant difference from 10 weeks onwards.

Wojcik *et al.* (1986) observed that serum iron values of 30 healthy goats ranged from 22-30 mol/l.

Biswas (1993) reported the serum iron value in Black Bengal goats to be  $0.48 \pm 0.04$  ppm in arsenic toxicated goats against the value  $0.98 \pm 0.01$  ppm of healthy control goats.

Bhattacharya *et al.* (1995) in a study of assessing serum iron concentration in Assam goats at different stages of reproduction, concluded that the serum Fe concentration was lowest in late pregnancy.

Khan *et al.* (1995) found no significant difference of iron concentration in muscle of goat between sexes. However age significantly influenced its level in muscle and liver.

Mondal (1995) obtained the serum iron value of the Black Bengal goats of Terai and Hill zones of West Bengal to be  $12.17 \pm 0.40$   $\mu\text{g/ml}$  and  $13.22 \pm 0.48$   $\mu\text{g/ml}$ , respectively. The zone effect, of course, did not cause any significant variation in the iron level.

Bhattacharya *et al.* (1996) observed significantly higher ( $P < 0.05$ ) levels of serum iron in winter ( $4.23 \pm 0.07$  ppm) than in summer ( $4.00 \pm 0.08$  ppm). The authors in the Assam goats opined that this increment of serum iron in winter might be due to increased number of circulating erythrocytes owing to stimulatory effect of corticosteroides and thyroxine on erythropoiesis, which in turn caused the elevation in blood Fe level.

Das (1997) reported that the serum iron value of Black Bengal goats in Red and Laterite zone ( $5.292 \pm 0.201$   $\mu\text{g/ml}$ ) was significantly higher ( $P < 0.01$ ) than New Alluvial zone ( $3.387 \pm 0.162$   $\mu\text{g/ml}$ ). He viewed that the lower level of serum iron might be due to less amount of Fe, Cu, Co in the grazing plants and high pH of the soil of New Alluvial zone.

Ramirez *et al.* (2001) reported that though being higher in summer and spring, Fe was present in substantial amount in the browse plant species of North-Eastern Mexico in all the seasons to meet adult goat requirements.

#### **2.4.2 Copper (cu)**

Wojcik *et al.* (1986) found that the serum copper values of 30 healthy exotic goats ranged from 12 – 14 m mol/l.

Grag *et al.* (1988) reported the mean serum copper value of Botswana goats to be  $149.94 \pm 71.14$   $\mu\text{g/dl}$ .

Nazki and Rattan (1990) estimated serum trace elements during different seasons in sheep and noted higher value of Cu in winter than summer. The authors also concluded that the variation might be due to the fact that, in winter, erythropoiesis is more, resulting in corresponding increase in blood Cu concentration during the season.

Nickert *et al.* (1990), in a survey of Angora goats and Merino sheep kept under similar feeding condition found that the goats showed higher concentration of serum copper (95 – 137  $\mu\text{g/dl}$ ) compared to sheeps (63 – 103  $\mu\text{g/dl}$ ).

A study was carried out by Bhattacharya *et al.* (1995) at different stages of reproduction of indigenous goats of Assam to access the serum trace minerals. Copper concentration was reported to be significantly higher on the day of estrus compared to other stages of reproduction.

Mondal (1995) recorded significantly higher ( $P < 0.01$ ) level of serum copper in Black Bengal goats reared in Hill zone ( $1.40 \pm 0.11$   $\mu\text{g/ml}$ ) than the goats in Terai zone ( $1.02 \pm 0.08$   $\mu\text{g/ml}$ ). He opined that the dropped level of copper was possibly due to deficiency of Cu in grazing plants, malabsorption, interference in uptake and inefficiency of liver in the goats of Terai zone.

The concentration of Cu was found to be significantly higher ( $P < 0.01$ ) in winter ( $1.68 \pm 0.4$  ppm) than summer ( $1.08 \pm 0.03$  ppm) in indigenous goats of Assam, as reported by Bhattacharya *et al.* (1996).

Das (1997) obtained a lower level of serum copper in Black Bengal goats in New Alluvial zone ( $1.118 \pm 0.111 \mu\text{g/ml}$ ) than in Red and Laterite zone ( $1.705 \pm 0.126 \mu\text{g/ml}$ ). The variation due to zones was reported to be statistically significant ( $P < 0.01$ ).

### **2.4.3 Zinc (Zn)**

Wojcik *et al.* (1986) found the serum Zn values of 30 healthy goats to range from 16 – 20 m mol/l.

Reuter and Bowden (1987) studied a herd of 120 Angora goats and found the plasma Zn values of those affected by alopecia and hyperkeratosis was  $62 \pm 14 \mu\text{g}/100 \text{ ml}$ . Supplementing  $\text{ZnSO}_4$  in the ration brought about an improvement and a rise in plasma Zn to  $140 \mu\text{g}/100 \text{ ml}$ .

Nickert *et al.* (1990) reported the serum Zn content of Angora kids, 12 months old goats and adult goats to be 105, 72 and  $67 \mu\text{g}/\text{dl}$ , respectively, there being a trend of decrease in the serum Zn content with the advancement of age. The age effect, however, was not statistically significant.

McDowell *et al.* (1991) estimated the serum Zn content to be  $0.54 \mu\text{g}/\text{ml}$  and  $0.83 \mu\text{g}/\text{ml}$  in goats affected by seasonal dermatitis and unaffected ones, respectively.

Sarkar *et al.* (1994), in a survey of 86 goats reared on grazing condition found that the serum Zn values (ppm) were  $0.83 \pm 0.08$  in dry season and  $0.96 \pm 0.08$  in wet season.

Bhattacharya *et al.* (1995) studied serum Zn values at different stages of reproduction in indigenous goats of Assam and observed the level to be significantly higher in the late pregnancy compared to that of other stages.

Khan *et al.* (1995) estimated trace element concentration in different tissues of goat and found that Zn was significantly higher in liver and muscles than kidney. Sex showed non-significant difference of Zn concentration in muscles.

Mondal (1995) estimated the Zn values of the blood of Black Bengal goats of the Terai and Hill zones. The value was reported to be higher ( $1.33 \pm 0.09 \mu\text{g/ml}$ ) in the goats of Terai zone than the Hill zone ( $0.98 \pm 0.08 \mu\text{g/ml}$ ). The zone effect on the variability of blood Zn was highly significant ( $P < 0.01$ ).

Bhattacharya *et al.* (1996) estimated the blood Zn value in Assam goats to be  $0.91 \pm 0.12$  ppm during summer and  $0.98 \pm 0.16$  ppm during winter. Though the winter Zn level was higher than that of summer, the variation due to season was, of course, not statistically significant.

According to Das (1997), the Black Bengal goats reared in Red and Laterite zone of West Bengal contained significantly higher amount of serum Zn ( $2.007 \pm 0.232 \mu\text{g/ml}$ ) compared to those at New Alluvial zone ( $1.192 \pm 0.201 \mu\text{g/ml}$ ), the zone effect in the serum Zn variation being highly significant.

Haldar *et al.* (1998) estimated serum Zn content in the pregnant as well as non-pregnant goats and also male goats of Barbari breed. Zn values were higher to be comparable in pregnant and male goats and lower in non-pregnant females.

Ramirez *et al.* (2001) evaluated few browse plant species in North-Eastern Mexico for comparative seasonal contents of different minerals and concluded that Zn in most plants had low marginal level to meet adult goat requirements and have to be included in the ration of range goats throughout the year.

#### **2.4.4 Manganese (Mn)**

Uranium and Feliciano - Silva (1984) observed low level of manganese ( $0.14 \pm 0.06 \mu\text{g/ml}$ ) after studying maternal blood samples of 59 goats which had early abortion.

Biswas (1993) reported the serum manganese value was  $0.21 \pm 0.01$  ppm in arsenic toxicated goats against the value of  $0.07 \pm 0.001$  ppm of healthy control goats.

Khan *et al.* (1995) observed significant difference of Mn level in liver between male and female and also young and old goats from Alabama.

Ramirez *et al.* (2001) reported that similar to Zn and Cu concentrations the browse plant species of North-Eastern Mexico contains low marginal level of Mn in all seasons of the year and hence range goats require dietary inclusion of Mn throughout the year.

#### **2.4.5 Cobalt (Co)**

McDowell (1992) reported that alkaline soil would reduce the Co uptake by the plants as compared to neutral or acidic soil. Depletion of Co content in high rainfall areas was also reported due to leaching of the element from top soil.

# CHAPTER-3

# MATERIALS AND METHODS

# **MATERIALS AND METHODS**

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The present investigation was undertaken on the Black Bengal goats covering the Terai and Hill agroclimatic zones of West Bengal during the years 1999 and 2000. The study was carried out exclusively under field condition (at farmers' door to door) for recording observations and generating data on different parameters of the Black Bengal goats in these zones. A brief account of the experimental techniques and the methods of analysis during the present study are given below.

## **3.1 Locations of the 2 Zones of Study**

### **3.1.1 Terai Zone**

The Terai zone of West Bengal is situated at a latitude of  $27^{\circ}$ N, longitude of  $89^{\circ}$ E and an altitude of 150 meter above the sea level which comprises of 32 blocks covering Cooch Behar, Jalpaiguri and parts of Uttar Dinajpur and Darjeeling districts (Fig. 1.1). Four villages viz., Pundibari, Sanjherpar, Chandan Choura and Dhandhinguri were selected at random for the investigation on Black Bengal goats at farmers' doors.

### **3.1.2 Hill Zone**

The Hill zone is situated at a latitude of  $27.5^{\circ}$  N, longitude of  $88.5^{\circ}$  E and at an altitude of 1200 meter above the sea level, being consisting of the hilly areas of Darjeeling district covering Darjeeling, Kurseong and Kalimpong subdivisions. Four randomly selected villages of this zone were Bomgbosti, Tashiding, Tanek and Nassay.

## **3.2 The Climates of the 2 Zones**

The period of investigation was conventionally divided into three seasons, viz., Summer (S) – March to June, Monsoon or Rainy (M) – July to October and Winter

(W) – November to February. The monthwise values of the climatic components in terms of temperature (maximum – minimum) and relative humidity (maximum – minimum) over the entire period of research investigation have been profiled in Table 3.1 and Table 3.2.

### **3.3 Animals under Investigation**

Among three strains/varieties (Black, Brown and White) of Bengal goats, the Black Bengal goats were chosen for the present investigation due to their abundance in the identified zones. A survey was made on the selected villages to detect the pregnant does with expected date of kidding (hearing from the farmers). A number of 119 does were observed from the 4 randomly selected villages of the Terai zone over the 2 years period of investigation and the does produced 221 kids. Similarly 94 does were recorded in Hill zone which produced 157 kids. Subsequently the kids were kept under observation for a period of six months, considering the usual practice of slaughtering male goats at 6 months of age especially in Terai zone. Various parameters of growth and physical measurements on the goats stated of the 2 zones constituted the experimental animals.

#### **3.3.1 Feeding of Goats**

Goats of the Terai zone principally thrive on grazing. Agricultural land after harvesting of crop, road-side grasses, tree leaves and weed grasses are the principal sources of feed of this region. The goats were allowed to graze throughout the day where practicable and were taken back to the house in the evening. Goats received no supplementary feed in the house excepting ample fresh drinking water. Hill goats, on the other hand were reared both by grazing and stall feeding. Tree fodders, agricultural by-products, vegetable waste, jungle grasses, unconventional plants and shrubs were generally offered to the stall fed hill goats. The goats were occasionally allowed to graze on the hill track to fulfill their nutritional demand.

#### **3.3.2 Housing of Goats**

No elaborate type of housing were provided to the goats of both the Terai and Hill zones. Terai goats had a small enclosure as their shelter, attached to the human

dwellings. Hill goats were housed mostly in small bamboo enclosures, raised from the ground and often with small open run. Fodders were provided in the feeding racks to minimize spoiling. The use of thatched roof stalls and stone wall enclosures were limited.

### **3.4 Production Performance Parameters and their Measurements**

Black Bengal goat is a poor milk producer just sufficient to nourish its kids and hence production performance were assessed in terms of its growth. The production traits in terms of live weight at different stages of growth were measured from birth to 180 days of age *viz.*, Birth weight, 30 day weight, 90 day weight and 180 day weight. The production traits were measured as below.

#### **3.4.1 Litter Size**

The number of kids born per doe per kidding was taken into account as litter size and designated as single, twins and triplets. Different parameters of individual kids of the same litter were observed separately. The effect of litter size were analysed statistically to examine its effect on the economic traits.

#### **3.4.2 Birth Weight**

Body weight of individual kid was recorded within two hours of birth except the night kidding where it was recorded in the next morning. Body weight was taken with the help of Dial-type spring balance (Salter, 20 kg capacity with 200g graduation) and expressed in kg.

#### **3.4.3 Growth**

Growth of individual kid was measured in terms of its body weight gain in the subsequent period profiled *viz.*, 30 day weight (30-D wt), 90 day weight (90-D wt) and 180 day weight (180-D wt) as included in the present investigation, both males and females being recorded to examine the sex effect. The weight was measured with the help of spring balance (Salter) and expressed in kg. The body weight was taken in the morning hours when no feed was offered to kids or before the kids were allowed for grazing. The rate of growth was estimated by dividing the body weight gain at any particular time by the days and expressed in g/day.

### **3.5 Physical Measurement Traits and their Measurements**

Different body measurements of goats taken at six months of age with the help of measuring tape and expressed in centimeter were as follows, the means of 3 readings for every body measurement being considered to be one observation for each animal :

#### **3.5.1 Body Length (BL)**

The oblique length taken by measuring the distance between shoulder point and pin bone constituted the body length (in cm).

#### **3.5.2 Height at Wither (WH)**

The distance between the ground and the level of wither was taken as height at wither of the animal (in cm).

#### **3.5.3 Heart Girth (HG)**

The circumference as measured surrounding the heart just behind the elbow constituted the heart girth of the animal (in cm).

#### **3.5.4 Paunch Girth (PG)**

The circumference of the body just behind the barrel and in front of the hind legs were recorded as the paunch girth (in cm).

#### **3.5.5 Cannon Circumference (CC)**

The girth of the cannon bone in the middle over the skin were recorded as the cannon circumference (in cm).

The physical measurements were recorded on the animals standing squarely on levelled ground and before feeding/grazing.

### **3.6 Haemato-constituent Parameters and their Estimates**

#### **3.6.1 Haematological Profiles**

Some total of 12 haematological parameters were studied taking blood samples from the goats of the Terai and Hill zones at the age of 6 months (180 days), the methods of which are being briefly accounted as below :

##### **3.6.1.1 Collection of Blood**

Blood samples were collected randomly from a number of 184 apparently healthy Black Bengal goats at six months of age, the number of goats being 94 and 90 at Terai and Hill zone, respectively. Venous blood was conveniently collected by jugular vein puncture, 5 ml of blood from each animal was drawn in a clean, dry and sterilized glass syringe; 2 ml of blood was allowed to flow out slowly in a sterilized glass vial containing ethylene diamine tetra-acetate (EDTA) @ 1 mg/ml of blood and the rest amount was placed in a test tube without having anticoagulant which was used for collection of serum. The vial containing EDTA was then rotated gently for proper mixing of blood with the anticoagulant and the same was then placed for estimation of different haematological parameters.

##### **3.6.1.2 Estimation of Haemoglobin (Hb)**

Hb was determined by Sahli's acid hematin method with the help of Hellige Sahli's haemoglobinometer as described by Schalm *et al.* (1975) and the value was expressed in g/dl.

##### **3.6.1.3 Estimation of Packed Cell Volume (PCV)**

PCV is the percentage of total volume occupied by packed erythrocytes when a given known volume of whole blood is centrifuged at a constant speed for a constant period of time. Wintrobe haematocrit tube was used for the estimation of PCV, as described by Sastry (1983). The tube filled with whole blood was centrifuged

in Remi Research Centrifuge Machine (R-2A) at 3000 r.p.m. until the PCV column had a translucent appearance, following the Koeppé's criterion for complete packing. PCV was expressed as a percentage.

#### 3.6.1.4 Total Erythrocytic Count (TEC) and Total Leucocytic Count (TLC)

The number of RBC and WBC in the specified areas of the <sup>Neubauer's</sup> Chamber were counted as per method described by Schalm *et al.* (1975) and calculated considering the area counted and dilution factor. The number of TEC and TLC were expressed as millions per cmm and thousands per cmm, respectively.

#### 3.6.1.5 Differential Leucocytic Count (DLC)

Different leucocytes *viz.*, Neutrophils, Eosinophils, Basophils, Lymphocytes and Monocytes, were counted from the blood smear under the microscope. One drop of freshly collected blood was taken on a grease-free slide and with the help of another slide an even and fairly thick blood smear was prepared from each sample. The smear on the slide was then dried at once by waving in the air. The blood smear was stained using Leishman's stain as per method following Sastry (1983). The buffer used for the purpose was prepared by dissolving 3.8 gm of disodium phosphate and 5.47 gm of monopotassium dihydrogen phosphate in 1000 ml distilled water. The different leucocytes counted were expressed as percentage.

#### 3.6.1.6 Estimation of MCV, MCH and MCHC

With the help of estimated value of Hb, PCV and TEC the value of MCV, MCH and MCHC could be determined by the following formulae as described by Sastry (1983) :

$$\text{MCV} = \frac{\text{PCV}}{\text{RBC in million}} \times 10 \text{ cubic microns}$$

$$\text{MCH} = \frac{\text{Hb in g/dl}}{\text{RBC in million}} \times 10 \text{ pico grams}$$

$$\text{MCHC} = \frac{\text{Hb in g/dl}}{\text{PCV}} \times 100 \text{ per cent}$$

### **3.6.2 Estimation of Serum Trace Minerals**

Serum iron, copper, zinc, manganese and cobalt were determined as per method described by Sandel (1950), modified by Arenze *et al.* (1977).

#### **3.6.2.1 Collection of Serum**

The test tube containing blood sample having no anticoagulant, was placed in slanting manner for about four hours for easy release and collection of serum. With the help of a micropipette one ml clear, non-haemolysed serum was slowly collected from each sample and placed in a separate container, corked properly and brought to the laboratory for further processing.

#### **3.6.2.2 Processing of Serum**

Serum was first centrifuged in Remi Research Centrifuge Machine (R-24) at 5000 rpm for 5 minutes. 0.5 ml of clear, supernatant, centrifuged serum was mixed with 2 ml of tri-acid mixture (Nitric acid – 10 parts, Perchloric acid – 4 parts and Sulphuric acid – 1 part) in the conical flask and placed on hot plate for digestion at 100<sup>0</sup>C for half an hour or till the mixture became colourless. The digested sample when cooled was diluted with a little triple distilled water and subsequently filtered through Whatman – 42 filter paper and finally diluted to a known volume with triple distilled water. The diluted samples were then placed in scintillation vials, corked properly, labelled and preserved in deep freeze at –20<sup>0</sup>C.

#### **3.6.2.3 Analysis of Serum Samples**

The diluted serum samples were brought to the Regional Sophisticated Instrumentation Centre at the Bose Institute, Kolkata, for estimation of serum trace minerals as specified earlier (Fe, Cu, Zn, Mg and Co). The standard solutions of each mineral were available in Bose Institute laboratory in different concentrations (ppm). The clear solutions were processed in Atomic Absorption Spectrophotometer (Varian Techtron, AA-575 ABQ) and the readings (ppm) were compared with standard solutions at different concentrations of iron, copper, zinc, manganese and cobalt for actual findings (in ppm). Considering the original volume of serum sample and

dilution factor, the final concentration of those trace elements were calculated and expressed as  $\mu\text{g/ml}$ .

### 3.7 Factors Considered to Affect the Production, Physical and Haemato-Constituent Parameters

Some of the factors (as effects) as considered to influence the production and physical measurement parameters in the Black Bengal goats were :

- (i) Zone : T = Terai, H = Hill
- (ii) Sex : M = Male, F = Female goat
- (iii) Litter size (Lt Sz) : 1, 2, 3
- (iv) Parity of kidding (Pty Kid) : 1, 2, ....., 9.
- (v) Season of birth (Sn Bt) : S, Ms, W

The haemato-constituent parameters were considered to be affected by :

- (i) Zone
- (ii) Sex and
- (iii) Season

S = Summer, M<sub>s</sub> = Monsoon, W = Winter.

The effects were ascertained through the LS – ANOVA and LS Means which were tested for significant variations through LSD or DMRT.

### 3.8 Statistical Methodology

To observe the main effect of zone, sex, litter size, parity of kidding and season of birth on growth and physical measurements, the non-orthogonal univariate analysis of variance was followed adopting the linear model as below :

$$Y_{ij} = \mu + x_i + e_{ij} \dots\dots\dots (A)$$

Where,  $Y_{ij}$ 's are either growth or physical measurements of  $j^{\text{th}}$  animal of  $i^{\text{th}}$  independent or predictor variable (x), say zone, sex, litter size etc.,

$i = 1$  and  $2$  for zone and sex

$= 1, 2$  and  $3$  for litter size and season of birth

$= 1, 2, \dots, 9$  for parity of kidding

$j = 1, 2, \dots, n$  (maximum 378) as available at the time of generation of respective data during experimentation.

$\mu$  = population mean.

$e_{ij}$ 's = the respective error variable following the normal and independent distribution with the parameter's mean as zero and variance as  $\sigma^2$ . The errors were also assumed to be non correlated.

The sum of squares (MSS) in the LS – ANOVA for the factors affecting and the LS-means (effect wise and general) were calculated developing constants for adjustments adopting Type – III sum of squares analysis. The LS-means (effect wise) were compared by multiple comparison through LSD test or Duncan's test as applicable whenever any significant effect causing variation was noticed.

The orthogonal univariate analysis of variance was followed while studying the haemato-constituent parameters. This analysis was made for pooled data of Terai and Hill zones together, following the model as below :

$$Y_{ij} = \mu + x_i + e_{ij} \dots \dots \dots (B)$$

Where,  $Y_{ij}$ 's are either haematological or serum trace mineral parameters of  $j^{\text{th}}$  animal of  $i^{\text{th}}$  independent or predictor variable (x), like zone, sex and season of collection,

$i = 1$  and  $2$  for zone and sex

$= 1, 2$  and  $3$  for season

$j = 1, 2, \dots, 184$

$\mu$  and  $e_{ij}$ 's are as per equation .... (A)

The correlations (Pearson) between the paired parameters of growth at different age (B wt, 30-D wt, 90-D wt, 180-D wt) and physical measurements (BL, WH, HG, PG and CC) at 180 days of age were obtained and the level of significance (2-tailed) were tested on the pooled observations of the goats of both the Terai and Hill zones.

For predicting live body weight from different body dimensional traits, the coefficient of both full model and step wise linear multiple regression equations of the body weight (Y) on body biometrics (X<sub>i</sub>) in different combinations were obtained following the model as below :

$$Y = b_0 + b_1 x_1 + b_2 x_2 + \dots + b_5 x_5$$

Where, Y is body weight at 180 days of age,

b<sub>i</sub> = partial regression coefficient of x<sub>i</sub>

x<sub>i</sub> = body biometrics (i = 1, 2, ..... 5)

and b<sub>0</sub> = constant or intercept.

To find out the growth pattern (pooled) of Black Bengal goat in parts of North Bengal, linear, quadratic, compound, growth and exponential models were fitted, the model expressions are being as below :

Linear :  $Y = b_0 + b_1 .t.$

Quadratic :  $Y = b_0 + b_1 t + b_2 .t^2$

Compound :  $Y = b_0 . b_1 . t.$

Growth :  $Y = \exp (b_0 + b_1 .t)$

Exponential :  $Y = b_0 . \exp (b_1 .t)$

Where Y is the observed body weight of Black Bengal goats. t is the time variable *i.e.* body weight on days after birth and b<sub>0</sub>, b<sub>1</sub>, b<sub>2</sub> ..... are unknown parameters.

The best fitted curve was found depending upon the observed data and the corresponding equation may act as best prediction equation to predict body weight with respect to age of the animal.

The statistical analysis of the data were made following the models and methods of Harvey (1966), Snedecor and Cochran (1967) and Becker (1975).

**Table 3.1 : Average values of climatic components of Terai Zone.**

Month	Components											
	Temperature (Max)			Temperature (Min)			R. H. (Max)			R. H. (Min)		
	1999	2000	Avg	1999	2000	Avg	1999	2000	Avg	1999	2000	Avg
January	21.90	22.90	22.40	9.40	8.80	9.10	95.40	97.00	96.20	58.20	53.00	55.60
February	26.30	24.30	25.30	11.40	8.80	10.10	94.70	95.00	94.85	47.40	46.00	46.70
March	28.20	28.80	28.50	14.20	14.20	14.20	89.70	88.00	88.85	51.20	46.00	48.60
April	30.10	31.00	30.55	17.30	18.10	17.70	93.20	91.70	92.45	64.70	62.80	63.75
May	33.20	33.40	33.30	24.20	23.80	24.00	91.40	93.30	92.35	63.50	65.70	64.60
June	32.10	31.45	31.77	24.30	23.20	23.75	95.30	96.83	96.06	79.50	71.86	75.68
July	30.30	31.85	31.07	23.20	23.53	23.36	98.00	96.48	97.24	83.10	70.35	76.73
August	31.30	31.69	31.49	24.10	23.33	23.71	98.10	96.81	97.45	87.20	70.71	78.95
September	33.60	30.53	32.06	23.50	21.61	22.55	96.10	96.90	96.50	69.20	74.43	71.81
October	30.30	31.74	31.02	19.50	18.99	19.24	93.80	93.06	93.43	73.60	60.55	67.07
November	20.90	27.70	24.3	16.60	14.32	15.46	92.20	95.93	94.06	67.50	63.30	65.40
December	23.30	24.20	23.75	11.20	10.80	11.00	94.20	92.87	93.53	71.30	65.60	68.45

**Table 3.2 : Average values of climatic components of Hill zone.**

Month	Components											
	Temperature (Max)			Temperature (Min)			R. H. (Max)			R. H. (Min)		
	1999	2000	Avg	1999	2000	Avg	1999	2000	Avg	1999	2000	Avg
January	20.84	17.88	19.36	8.35	8.84	8.59	71.77	81.79	76.78	49.16	63.00	56.08
February	24.46	17.31	20.88	13.82	8.96	11.39	75.43	78.50	76.96	54.18	61.08	57.63
March	26.26	22.70	24.48	14.77	12.60	13.68	63.52	67.95	65.73	44.27	55.84	50.05
April	28.79	25.71	27.25	19.04	16.71	17.87	81.15	77.85	79.50	60.78	63.52	62.15
May	28.00	26.64	27.32	19.92	19.84	19.88	88.70	87.21	87.95	77.23	76.96	77.09
June	29.45	27.20	28.32	20.18	21.20	20.69	88.89	92.87	90.88	76.03	86.37	81.20
July	26.77	26.20	26.48	20.57	21.80	21.18	93.20	96.00	94.60	86.72	84.04	85.38
August	26.69	26.54	26.61	20.58	21.62	21.10	94.22	95.62	94.92	88.31	86.21	87.26
September	27.37	24.88	26.12	20.15	19.72	19.93	93.15	98.15	95.65	84.07	90.84	87.45
October	25.96	25.67	25.81	17.48	17.71	17.59	85.50	87.96	86.73	72.64	71.75	72.19
November	22.69	21.87	22.28	14.67	14.70	14.68	81.21	88.20	84.71	66.67	73.93	70.32
December	20.04	21.04	20.72	9.52	10.14	9.83	75.88	90.23	83.05	57.50	69.32	63.41

# CHAPTER-4

# RESULTS AND DISCUSSION

# RESULTS AND DISCUSSION

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The different production, physical measurement and haemato-constituent (haematological and serum trace minerals) parameters were studied in the Black Bengal goats of Terai and Hill zones of West Bengal under field conditions along with the various factors influencing these parameters. The correlation-regression studies were also made between the various growth and physical parameters. The results of all the estimates indicated are being presented and discussed.

## 4.1 Production Performance

The various production parameters were studied taking randomly 378 goats (kids at birth) and the production parameters being considered were : litter size, birth weight and body weight at 30, 90 and 180 days of age.

### 4.1.1 Litter Size

The average litter size of the Black Bengal goats (does) based on the 213 kiddings in the Terai and Hill zones (pooled) have been presented in Table 4.1. The zone and parity wise litter sizes have been presented in Table 4.1 and also in the bar diagram (Fig. 4.1). The percentage distribution of litter sizes (singles, twins and triplets) of Terai, Hill and pooled over zones have been presented through pie diagram in Fig. 4.2. As in the Table 4.1, the average litter size of Black Bengal goats was obtained to be  $1.769 \pm 0.611$ .

Information of the litter size of Black Bengal goats are not much. Almost similar litter size as in the present finding were reported by Hussain and Islam (1992), Alam (1992) and Singh & Singh (1999) in Black Bengal goats. Comparatively higher litter size were reported by Singh and Sengar (1978) and Moulick *et al.* (1966) at the UP and Haringhata Farm, respectively. Verma (1991), reported lower litter size (1.26) in Black Bengal goats. It seems crossbreeding of Black Bengal goats with other breeds has not yielded higher litter size (nor even exceeding 1.40 as per Singh and Singh, 1999). The purebreds like Jamunapari, Beetal and Barbari appear to yield lower litter sizes not exceeding 1.5 (Singh and Sengar, 1978).

**Table 4.1 : Average Litter Size of Black Bengal goats of Terai and Hill zones of West Bengal.**

Status	No. of obs	Litter size ( $\pm$ SE)
Pooled	213	1.769 $\pm$ 0.611
Terai zone	119	1.857 $\pm$ 0.625
Hill zone	94	1.659 $\pm$ 0.575
Pooled – 1 <sup>st</sup> kidding	26	1.115 $\pm$ 0.319
2 <sup>nd</sup> kidding	37	1.513 $\pm$ 0.512
3 <sup>rd</sup> kidding	55	1.759 $\pm$ 0.636
4 <sup>th</sup> kidding	45	2.000 $\pm$ 0.557
5 <sup>th</sup> kidding	26	2.148 $\pm$ 0.452
6 <sup>th</sup> kidding	9	1.777 $\pm$ 0.415
7 <sup>th</sup> kidding	13	2.076 $\pm$ 0.474
8 <sup>th</sup> kidding	1	2.000 $\pm$ 0.000
9 <sup>th</sup> kidding	1	3.000 $\pm$ 0.000

**Table 4.2 : Means of the production performance parameters of Black Bengal goats of Terai and Hill zones of West Bengal.**

Traits	No. of obs	Mean	SE	CV (%)
Birth wt (kg)	378	1.141	0.011	18.84
30-D wt (kg)	372	3.629	0.036	19.15
90-D wt (kg)	367	6.418	0.052	15.43
180-D wt (kg)	324	9.997	0.080	14.45

#### 4.1.1.1 Factors Considered to Affect Litter Size

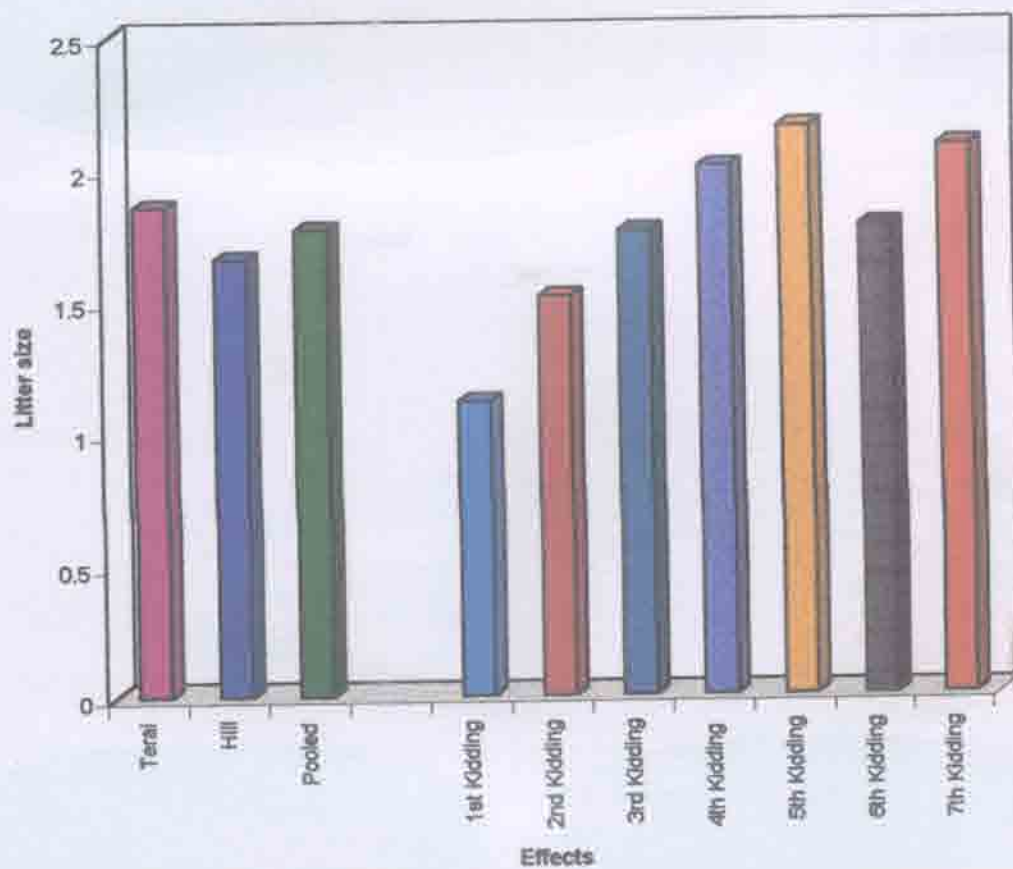
From Table 4.1 as well as bar diagram (Fig. 4.1) it is apparent that the litter size of Black Bengal goats of the Terai Zone was appreciably higher ( $1.857 \pm 0.625$ ) than that of the goats under Hill zone ( $1.659 \pm 0.575$ ). The reason of such significant variation in litter size due to zone effect might be ascribed to genetic as well as climatic causes. The Hill goats under the cold climatic stress and zonally limited breeding status might have led to a separate strain of Black Bengal having lower fertility/fecundity and thus the percentage of single births being more (vide pie diagram, Fig. 4.2).

The litter size at different parity of kidding of Black Bengal does as in Table 4.1 has yielded a trend of increase from  $1.115 \pm 0.319$  to  $2.148 \pm 0.452$  upto 5<sup>th</sup> parity of kidding. From 6<sup>th</sup> parity to 9<sup>th</sup> parity the litter size was not of any definite trend. The increasing trend of litter size upto 5<sup>th</sup> was obviously due to physiological reasons *viz.*, age and weight of maturity (including sexual maturity) and increase in reproductive capacity or fecundity of the does. The number of observations of the litter size after 5<sup>th</sup> parity was not enough to conclude a definite trend. Information on this aspect of parity effect on litter size is limited. Hussain and Islam (1992) under field condition of Bangladesh and Singh and Singh (1999) under farm condition at UP observed such trend of higher litter size with the advancement of parity upto 4<sup>th</sup> (and not at the 5<sup>th</sup> parity as in the present study).

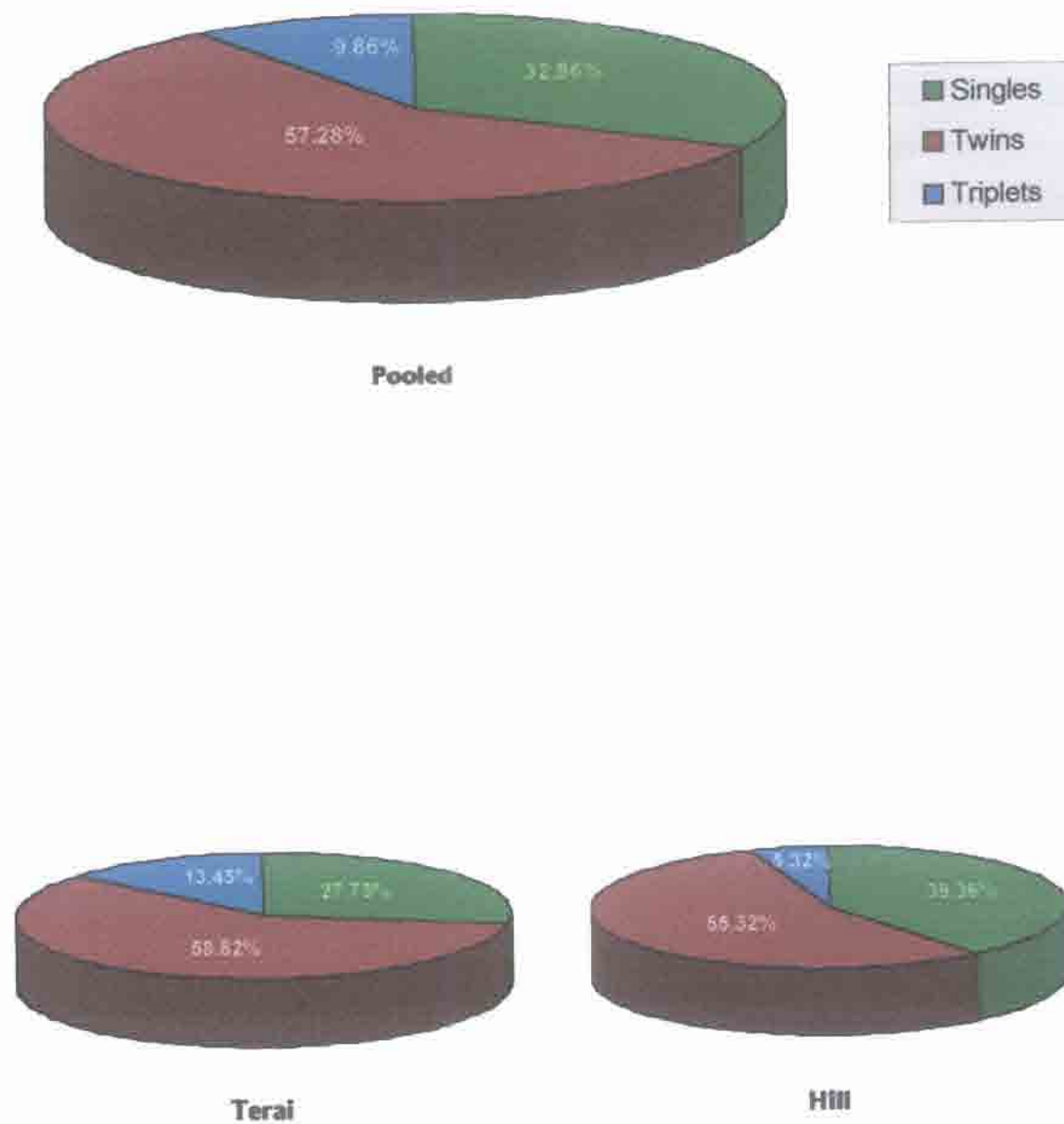
#### 4.1.2 Birth Weight

The mean birth weight including SE and CV of 378 Black Bengal kids born under the field conditions of Terai and Hill zones as estimated is presented in Table 4.2. The effectwise (zone, sex, litter size, parity and season of birth) LS means of birth weight along with the LS-ANOVA have been presented in Table 4.3 and Annex Table 1.

As it appears from Table 4.2, the mean birth weight of Black Bengal goats under field conditions at the 2 zones (pooled) were  $1.141 \pm 0.011$  kg with the coefficient of variation of 18.84 per cent. Birth weight of goats (kids) as well as other



**Fig. 4.1 :** Litter size of Black Bengal goats of Terai and Hill zones of West Bengal



**Fig. 4.2 : Percentage distribution of litter size of Black Bengal goats**

livestock is a trait of economic importance as it has the direct (positive) bearings with the weight gain of the kids at the subsequent stages of development. Research informations on the birth weight of Black Bengal kids including other breeds are available mostly based on the goats under farm controlled management.

The present finding corroborates the findings of Malik *et al.* (1986), Pattanaik and Mishra (1985) and Gupta *et al.* (1989) in Black Bengal kids. The lower birth weight than the present finding were reported by Acharya (1992), Islam and Rahman (1992), Ali *et al.* (1993) and Husain *et al.* (1997) in Black Bengal kids. Birth weight higher (1.21 to 1.48 kg) than the present finding were obtained by Acharya (1982), Kumar and Singh (1983), Dron (1987), Mishra (1987), Patnaik and Nayak (1988), Singh *et al.* (1991), Chatterjee (1992), Mia *et al.* (1993) and Singh (1999) in the Black Bengal kids under farm management status.

Higher and widely ranged birth weight of the Barbari (1.80 to 2.22 kg), Beetal (2.22 to 2.80 kg), Ganjam (2.45 kg) and Jamunapari (2.84 to even 4.39 kg) goats were obtained by various other workers (Bhatnagar *et al.*, 1971; Singh, 1973; Mittal and Pandey, 1974; Mishra, 1976; Khan *et al.*, 1979; Khan and Sahni, 1983; Kumar and Singh, 1983; Sinha and Sahni, 1983; Malik *et al.*, 1993. Information on the birth weight of Black Bengal goats or any other goat under field condition is scanty. Husain and Islam (1992) obtained the birth weight of field Black Bengal goats of Bangladesh to be 0.97 kg (lower than the present finding) and Pattanaik and Mishra (1985) in Orissa reported the value to be 1.20 kg, being mostly similar with the present finding.

From the works of Singh *et al.* (1981), Kumar and Singh (*loc. cit.*), Mia *et al.* (*loc. cit.*) and Singh (*loc. cit.*), it appears that crossbreeding of Beetal and Barbari with Black Bengal have resulted anticipated higher birth weight and crossbreeding of Jamunapari have resulted lower and inconsistent birth weight with Black Bengal combination.

#### **4.1.2.1 Factors Considered to Affect the Birth Weight**

The Annex Table 1 and the Table 4.3 indicate that the zonal effect on the variabilities of the birth weight in the Black Bengal kids were highly significant, the

birth weight being significantly ( $P < 0.01$ ) higher at the Hill zone. Such zonal/regional variability studies in the birth weight is limited except Husain *et al.* (1997), who in Bangladesh observed higher birth weight of Black Bengal kids in 3 zones out of 4 and in the 4<sup>th</sup> zone the birth weight was significantly lower. The Hill Black Bengal goats in the present study may be genetically different than Terai goats tending to a separate strain, and Hill goats live and thrive under better feeding status, both favouring to yield kids with higher weight at birth.

As in LS-ANOVA Table 1 and effectwise LS-mean Table 4.3 the sex effect on the variation of birth weight of the Black Bengal kids was significant ( $p < 0.01$ ), the male kids weighing higher than the females ( $1.207 \pm 0.015$  kg vs  $1.072 \pm 0.014$  kg). Similar type of finding was also reported by Gupta *et al.* (1989), Chatterjee (loc. cit), Islam and Rahman (1992), Husain *et al.* (loc. cit), Singh (loc. cit) and Das & Roy (1999) in Black Bengal kids. The observations on some other Indian goat breeds were in agreement with the present finding as reported by Prasad *et al.* (1971), and Sinha and Sahni (loc. cit) in Barbari; Singh (loc. cit), Khan and Sahni (loc. cit.) and Sinha & Sahni (loc. cit) in Jamunapari and Das *et al.* (1992) in Assam Hill goats. The Black Bengal half-breds had also produced heavier male kids (Singh *et al.*, 1977; Singh & Singh, 1998, and Singh, 1999). Genetically and physiologically the male foetus in the womb derives better status to develop and takes birth with higher weight in goats (as well as in all livestock/mammals). Ali and Hasnath (1977) and Khan *et al.* (loc. cit.), of course did not notice any appreciable effect of sex on the birth weight of Black Bengal and Jamunapari kids, respectively. Pattanaik and Nayak (loc. cit.) even observed the female Black Bengal kids to be heavier than the males at Orissa, which is interesting but not explainable.

Highly significant ( $P < 0.01$ ) effect of litter size on the birth weight of Black Bengal kids were observed in the present finding (Annex Table 1), the singles were noted to be heavier than twins and the twins were heavier than triplets as well (Table 4.3). The findings of the present study were in accordance with those reported by Sharma *et al.* (1981), Sinha & Sahni (loc. cit.), Malik and Islam (loc. cit.), Singh (1999) in Black Bengal kids. The birth weight was reported to be inversely related to the litter size in some other Indian goat breeds as noted by Singh (loc. cit.), Khan &

**Table 4.3 : Effectwise LS-means of the production performance parameters of Black Bengal goats of Terai and Hill zones of West Bengal.**

Effects & levels	Growth traits (kg)							
	Birth wt	± SE	30-D wt	± SE	90-D wt	± SE	180-D wt	± SE
<b>Zone</b>								
T	1.047 <sup>b</sup>	0.010	3.398 <sup>b</sup>	0.045	6.155 <sup>b</sup>	0.056	9.561 <sup>b</sup>	0.095
H	1.275 <sup>a</sup>	0.017	3.953 <sup>a</sup>	0.049	6.786 <sup>a</sup>	0.088	10.549 <sup>a</sup>	0.121
<b>Sex</b>								
Male	1.207 <sup>a</sup>	0.015	3.825 <sup>a</sup>	0.048	6.729 <sup>a</sup>	0.067	10.642 <sup>a</sup>	0.099
Female	1.072 <sup>b</sup>	0.014	3.421 <sup>b</sup>	0.049	6.095 <sup>b</sup>	0.071	9.399 <sup>b</sup>	0.105
<b>Litter size</b>								
1	1.315 <sup>a</sup>	0.033	4.133 <sup>a</sup>	0.096	7.103 <sup>a</sup>	0.151	10.922 <sup>a</sup>	0.233
2	1.126 <sup>b</sup>	0.011	3.581 <sup>b</sup>	0.039	6.355 <sup>b</sup>	0.055	9.917 <sup>b</sup>	0.079
3	1.006 <sup>c</sup>	0.016	3.334 <sup>c</sup>	0.072	5.908 <sup>c</sup>	0.099	9.133 <sup>c</sup>	0.183
<b>Pty Kid</b>								
1	1.159 <sup>a</sup>	0.039	3.585	0.132	6.178 <sup>ab</sup>	0.188	9.824 <sup>b</sup>	0.285
2	1.245 <sup>a</sup>	0.034	3.851	0.093	6.781 <sup>ab</sup>	0.133	10.657 <sup>a</sup>	0.208
3	1.148 <sup>ab</sup>	0.021	3.663	0.070	6.532 <sup>ab</sup>	0.100	9.974 <sup>b</sup>	0.152
4	1.101 <sup>ab</sup>	0.022	3.514	0.073	6.241 <sup>ab</sup>	0.105	9.690 <sup>b</sup>	0.160
5	1.084 <sup>ab</sup>	0.027	3.469	0.090	6.235 <sup>ab</sup>	0.129	9.969 <sup>b</sup>	0.204
6	1.250 <sup>a</sup>	0.052	3.944	0.172	6.593 <sup>ab</sup>	0.252	10.369 <sup>ab</sup>	0.395
7	1.093 <sup>ab</sup>	0.040	3.326	0.132	6.389 <sup>ab</sup>	0.188	9.644 <sup>b</sup>	0.336
8	1.250 <sup>a</sup>	0.040	3.950	0.486	7.150 <sup>a</sup>	0.691	10.650 <sup>ab</sup>	1.088
9	0.933 <sup>b</sup>	0.147	3.533	0.486	5.933 <sup>b</sup>	0.564	10.400 <sup>ab</sup>	0.823
<b>Sn Bt</b>								
S	1.150	0.018	3.573	0.058	6.441	0.084	10.039	0.129
M	1.130	0.026	3.671	0.086	6.272	0.123	9.917	0.190
W	1.139	0.07	3.662	0.054	6.452	0.079	9.993	0.087

Same alphabets in superscripts denote no significant difference at 5% level

Note : The terms Pty kid and Sn Bt denote parity of kidding and season of birth, respectively.

Sahni (loc. cit.) and Sinha & Sahni (loc. cit.) in Jamunapari; Sinha and Sahni (loc. cit.) in Barbari; Sinha & Sahni (loc. cit.) and Malik *et al.* (loc. cit.) in Beetal and Das *et al.* (loc. cit.) in Assam Hill goats. The sharing of uterine space and also the maternal nutrition by the multiple foetus in their prenatal stage might be the possible cause of proportionately lower birth weight of the multiple birth than that of single born kids. The crossbreds involving Black Bengal also showed the similar trend as per the present findings (Singh *et al.*, 1977 and Singh, 1999).

It is apparent from the Annex Table 1 that the parity of kidding of does significantly ( $P < 0.05$ ) influenced the birth weight of their progeny kids. The birth weight was recorded to be highest in 6<sup>th</sup> kidding followed by 2<sup>nd</sup> and lowest in 9<sup>th</sup> kidding, indicating that the increment did not follow any definite trend. The present finding supports Prasad *et al.* (1971) and Husain and Islam (loc. cit.). Singh and Singh (1999), of course, noticed increase of birth weight of Black Bengal kids with the advancement of parity of dam-does.

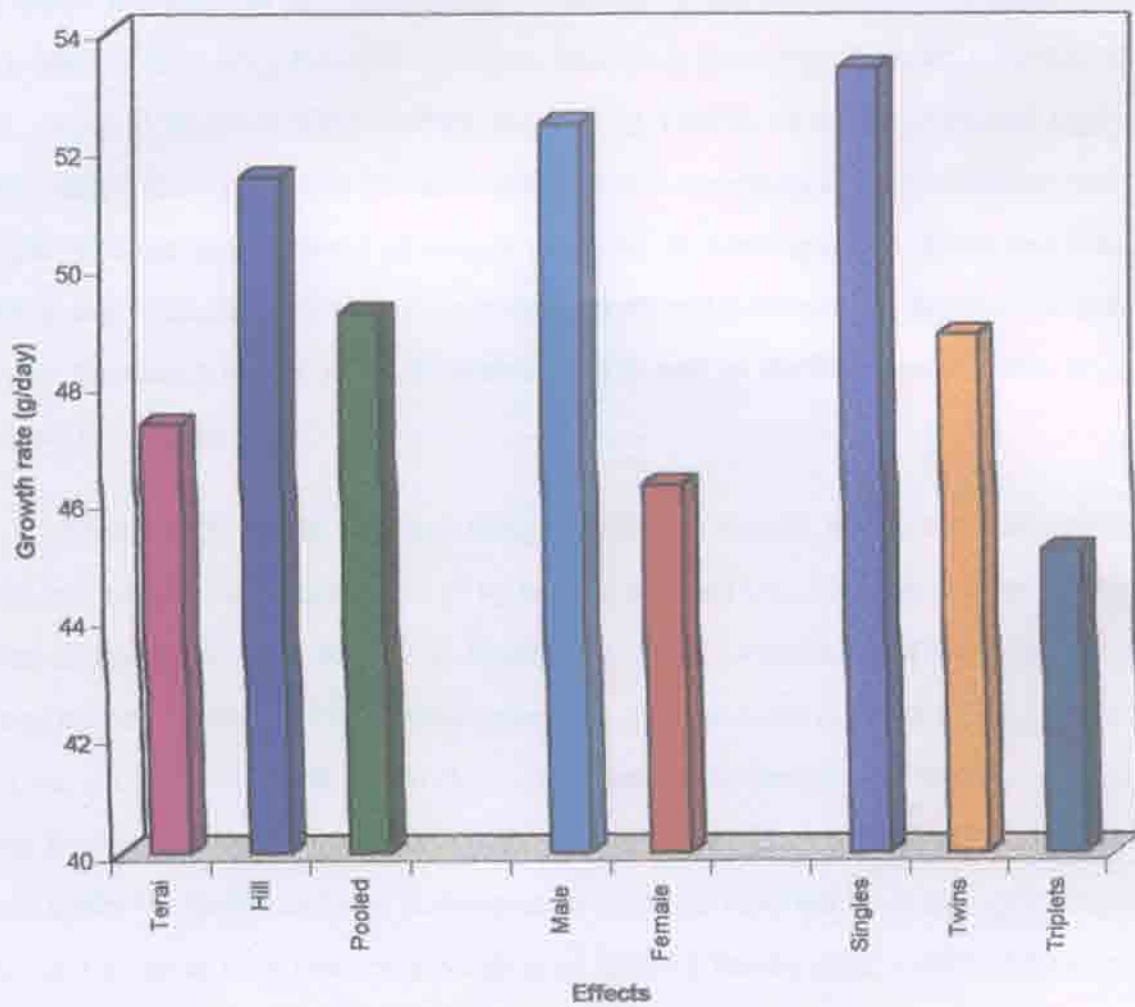
No appreciable effect of season of birth on birth weight of Black Bengal kids was noticed in the present study (Annex Table 1). Summer born kids were observed to have appreciably higher (though statistically insignificant) birth weight than either of the monsoon or winter births (Table 4.3). Significantly lower birth weight of monsoon born kids were reported by Singh, (loc. cit.), in crossbreds involving Black Bengal goats. Das and Roy (loc. cit.) in Black Bengal and Singh *et al.* (loc. cit.) in crossbreds obtained significantly higher birth in monsoon born kids, the value being significantly higher in summer born kids (Sinha and Sahni, 1983). Prasad *et al.* (1971) and Singh (loc. cit.) did not find any seasonal variation of birth weight in Barbari and Jamunapari kids, respectively, as per the present finding.

#### **4.1.3 Growth**

The mean (with SE & CV%) body weight of the Black Bengal kids of the Terai and Hill zones (pooled) at 3 different ages have been presented in Table 4.2. The average body weight of Black Bengal kids at 30, 90 and 180 days of age were estimated to be  $3.629 \pm 0.036$ ,  $6.418 \pm 0.052$  and  $9.997 \pm 0.080$  kg, respectively. The weight at one month was observed to be lower (2.74 to 3.18 kg) in Black Bengal and

**Table 4.4 : Average Growth Rate (g/day) of Black Bengal goats of Terai and Hill zones of West Bengal.**

Status			Growth rate (weight gain in g per day)			
			0-30 days	31-90 days	91-180 days	Overall
Zone	Terai		78.37	45.95	37.84	47.30
	Hill		89.27	47.22	41.81	51.52
	Overall		82.93	46.48	39.77	49.20
Sex	Terai	Male	81.77	47.25	42.14	50.45
		Female	74.90	44.75	34.68	44.74
	Hill	Male	94.43	49.92	44.18	54.47
		Female	83.37	44.28	39.49	48.40
	Overall	Male	87.27	48.40	43.48	52.42
		Female	78.30	44.57	36.71	46.26
Litter size	Terai	Single	81.20	46.65	38.37	48.27
		Twins	77.27	45.27	39.92	47.93
		Triplets	77.23	43.83	34.92	44.97
	Hill	Single	102.03	53.07	45.97	57.68
		Twins	86.37	46.10	40.28	49.90
		Triplets	78.23	40.00	38.59	45.67
	Overall	Single	93.93	49.50	42.43	53.37
		Twins	81.83	46.23	39.58	48.83
		Triplets	77.60	42.90	35.83	45.15

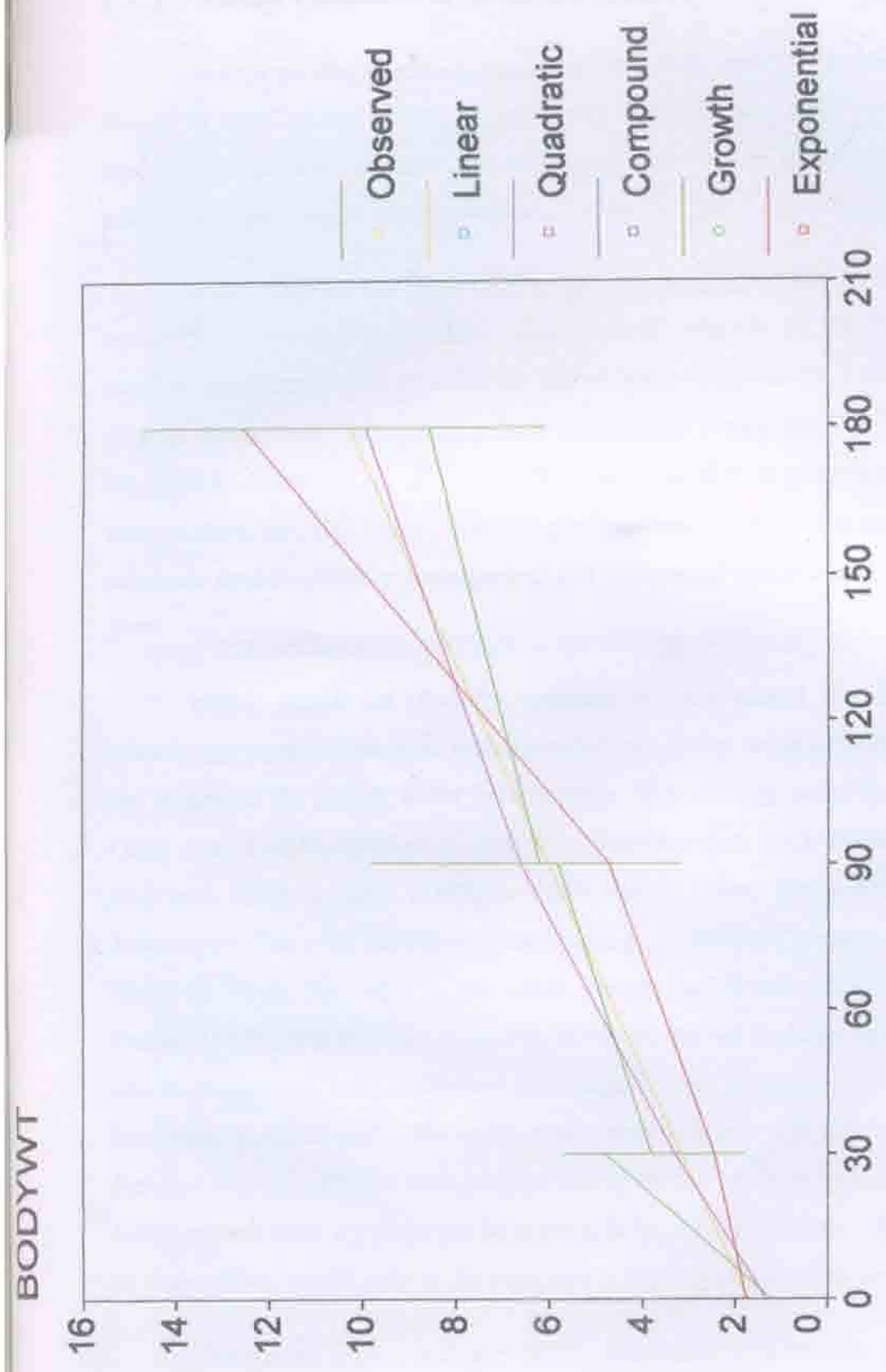


**Fig. 4.3: Growth rate (g/day) of Black Bengal goats of Terai and Hill zones of West Bengal**

Black Bengal half-breds with Jamunapari by Kumar and Singh (*loc. cit.*), in Black Bengal and Black Bengal half-breds with Beetal by Singh and Singh (1998). Jamunapari and deshi goats of Makhdoom were obtained to be much heavier at one month of age by Singh *et al.* (1981), and Khan & Sahni (*loc. cit.*).

Widely ranged body weight (4.30 to 5.89), lower than the present finding in the Black Bengal kids at 3 months were reported by Ali *et al.* (*loc. cit.*), Dron (*loc. cit.*), Mishra (*loc. cit.*), Pattnaik & Nayak (*loc. cit.*), Chatterjee (*loc. cit.*), Mia *et al.* (*loc. cit.*) and Singh & Singh (1998). Singh *et al.* (1991), of course, obtained higher body weight (6.88 kg) of the Black Bengal kids at 3 months of age. Much higher body weight at three months were obviously obtained in Jamunapari by Khan and Bhat (1981), and Khan & Sahni (*loc. cit.*), in deshi goats of Makhdoom by Singh *et al.* (*loc. cit.*), in Ganjam goats by Patra & Mishra (1987), and in Barbari goats by Mia *et al.* (*loc. cit.*).

Lower body weight of Black Bengal goats at 6 months of age with the similar trend at 3 months were also reported by several workers *viz.*, Singh & Sengar (1978), Khan & Bhat (*loc. cit.*), Kumar & Singh (*loc. cit.*), Pattanaik & Mishra (*loc. cit.*), Dron (*loc. cit.*), Mishra (1987), Chatterjee (*loc. cit.*), Hussain & Islam (1992), Mia *et al.* (*loc. cit.*) and Singh & Singh (*loc. cit.*). The Black Bengal half-breds and some other Indian goat breeds performed better at 6 months of age than the Black Bengal goats under the field condition at the present study as reported by Singh and Sengar (*loc. cit.*) Khan & Bhat (*loc. cit.*), Singh *et al.* (1981), Pander *et al.* (1987), Mia *et al.* (*loc. cit.*), Mahapatra & Nayak (1996), and Singh & Singh (1998). It is apparent from the present findings that the body weight in all the 3 stages were higher in the Black Bengal goats of Terai and Hill zones under field condition as compared to weight gains in the same breed at other locations (mostly under farm management). Due to high rainfall, soil condition and other associated factors, the availability of greens in the locations under investigation were more and this nutritional variation might explain the possible reason for higher growth of the Black Bengal goats under present study than those reported by several workers.



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Fig 4.4: Fitted curves indicating growth of Black Bengal goats

#### 4.1.3.1 Factors Considered to Affect the Growth

To find out the effects of zone, sex, litter size, parity of kidding of does and season of birth on the growth parameters of Black Bengal goats under the present study, the data were put for LS-analysis of variance as in Annex Table 1. The effectwise LS-means of growth parameters were also obtained as in Table 4.3.

It appears from the Annex Table 1, the zonal effect on the variabilities of body weight was observed to be highly significant ( $P < 0.01$ ) at all the stages of growth studied, the goats of Hill zone having higher body weight at the 3 different stages of growth. Such zonal variation on growth in the Black Bengal goats of Bangladesh was reported by Husain *et al.* (loc. cit.). The zonal variation in growth of Black Bengal kids of Terai and Hill zones under the present study might be due to the variation in adequate feed availability, management and differential climatic stress throughout the year.

Highly significant ( $P < 0.01$ ) variation in body weight at different stages of growth due to sex of the kids were recorded, the males being heavier ( $P < 0.01$ ) at all the stages of the growth under investigation. The findings were in agreement with Guha *et al.* (1968), Singh *et al.* (loc. cit.), Chatterjee (loc. Cit.), Husain & Islam (loc. cit.), and Singh & Singh (1998) in Black Bengal goats, Singh & Singh (1974) in Jamunapari, Das *et al.* (1993) in Assam local goats and their crosses with Beetal, and Singh & Singh (loc. cit.) in the Black Bengal half-breeds with Beetal. Mittal & Pandey (1978), and Majid *et al.* (1999), however, did not find any significant effect of sex on the growth traits in Barbari and Black Bengal goats, respectively. Like other livestock, conventionally the male goats at any given age are heavier than the females. Due to secretion of androgen (having anabolic effect) from the male gonads, faster growth rates are observed in males (Hafez, 1974), and this might be the cause of higher body weight gain of the male kids at the various stages of growth.

The Annex Table 1 indicates highly significant ( $P < 0.01$ ) effect of litter size on the body weight of Black Bengal kids at all the 3 stages of growth, the singles being heavier than twins, and the triplets, inferior to twins (Table 4.3). Significant variations of growth due to the effect of litter size were also reported by Malik *et al.* (loc. cit.),



**Fig. 4.5 : Day-old twin kids with the doe at Terai zone.**



**Fig. 4.6 : Day-old twin kids with the doe at Hill zone.**

Husain *et al.* (loc. cit.), Singh (loc. cit.) and Singh & Singh (1998) in Black Bengal kids. Higher growth of single birth compared to multiples as in the present study were also supported by Sarma *et al.* (1981) in Assam local, Khan & Sahni (loc. cit.) and Singh (1998) in Jamunapari, Malik *et al.* (loc. cit.), Singh (loc. cit.) and Singh & Singh (1998) in Beetal and Beetal x Black Bengal goats. Guha *et al.* (1968) and Singh & Singh (1974), on the other hand, observed non-significant effect of litter size on the growth of Black Bengal and Jamunapari kids, respectively. In the present finding, the single born kids were observed to be heavier than the multiples at birth and the singles continued to become heavier at the subsequent stages of growth even under the field conditions of 2 zones. This might be due to the difference in the initial body weight, its positive association with weights at later stages of life and feeding status in the pre-weaning stage.

The parity effect of dam-does on the growth of Black Bengal progeny kids were found to be significant ( $P < 0.05$ ) at 90 and 180 days of age, the effect being non-significant at 30 days. The parity effectwise LS-means also did not highlight any trend on the growth at any stage of development as studied. Information in this line is also lacking.

The season of birth did not show any appreciable effect on the growth of Black Bengal kids at different stages under the present investigation. The monsoon born kids at 30 days, winter borns at 90 days and summerborns at 180 days were recorded to be heaviest, the variation being non-significant. Similar trend of findings were also reported by Sharma *et al.* (loc. cit.), in Assam local, Singh (loc. cit.) in Black Bengal, Jamunapari and Beetal, and Singh & Singh (1998) in Black Bengal & Black Bengal x Beetal kids. The influence of season on the growth of goats were observed by Guha *et al.* (1968) in Black Bengal, Khan & Sahni (1983) in Jamunapari and Singh & Singh (loc. cit.) in BB x JP kids.

#### **4.1.3.2 Growth Rate**

The average daily weight gain in Black Bengal kids as were estimated under the field conditions of the Terai and Hill zones during different periods of growth *viz.*, 0 – 30 days, 31 – 90 days, 91 – 180 days and 0 – 180 days (overall rate of gain) have

been presented in Table 4.4 and the Bar Diagram (Fig. 4.3). Least square analysis of variance was also carried out to ascertain the variabilities of growth rate caused by the effects like zone, sex and litter size.

As it transpires from the Table 4.4 and Fig. 4.3, the average daily body weight gain of the Black Bengal goats (kids) of the Terai and Hill zones during 0 – 30 days, 31 – 90 days, 91 – 180 days and 0 – 180 days (over all) were estimated to be 82.93, 46.48, 39.77 and 49.20 g/day, respectively, the rate being highest in the 1<sup>st</sup> month followed by gradual decrease in the subsequent periods. The present findings clearly indicated that the daily weight gain in Black Bengal goats decreased with the advancement of age, and the growth estimates were well in agreement with Pattanaik & Mishra (1985) in Black Bengal goats at Orissa and also Patro & Mishra (1987) in Ganjam goats. Lower growth rates than in the present finding were reported by Ali (1980), Husain & Islam (loc. cit.), and Kumar & Mishra (loc. cit.) in Black Bengal goats and by Patro & Mishra in Ganjam goats.

Highly significant ( $P < 0.01$ ) variations due to zone effect in the growth rates of Black Bengal goats during 0 – 30 days, 91 – 180 days and 0 – 180 days were observed, the rates being significantly higher in Hill goats than the Terai (Table 4.4). Husain *et al.* (loc. cit.) also reported wide location-variation in the rates of weight gain in Black Bengal goats at Bangladesh, the rates being 38.212 to 51.912 g/day. In Black Bengal goats, Ali (1979) observed the growth rate to be regular and in straight line upto one year of age.

The sex effect on the variabilities of growth rates was observed to be highly significant ( $P < 0.01$ ) in the Black Bengal goats under such field conditions of Terai and Hill zones, the males obviously being heavier at all the periods of growth studied (Table 4.4) and the overall growth rates being 52.42 and 46.26 g/day in males and females, respectively. The growth rates obtained to be markedly lower in the Black Bengal goats of Bangladesh (42.89 vs 38.39 g/day) by Husain & Islam (1992).

Litter size effect was also observed to be highly significant ( $P < 0.01$ ) on the daily average weight gain in the Black Bengal goats in the present investigation. The rates of growth at all stages were highest in singles followed by twins and triplets



**Fig. 4.7 : Triplets at 30 days of age with the doe at Terai zone.**



**Fig. 4.8 : A female Black Bengal kid at 90 days of age at Terai zone.**

(Table 4.4). Lower growth rates in singles, twins and triplets in similar stages were reported by Sarma (1981) in Assam local, and Malik *et al.* (1986), in Black Bengal, Beetal and their crosses.

The growth rates in Black Bengal goats at Terai and Hill zones upto 6 months of age as could be studied appear to be higher even under field conditions which is really encouraging to produce high producing Bengal goats adopting proper selection programmes.

Different growth models were tried assuming days after birth (time) as the predictor variable to predict the body weight as time dependent response variable in the Black Bengal goats of Terai and Hill zones, and the models tried were-linear, quadratic, compound, growth and exponential along with corresponding coefficients as included in Annex Table 5 and the growth curves in Fig. 4.4

From the Annex Table 5 as well as the fitted growth curves in Fig. 4.4, it transpires that the quadratic model be accepted as the best fitted growth model for ascertaining the growth pattern of the Black Bengal goats under field conditions of the Terai and Hill zones, as it (the curve model) explains the highest  $R^2$  value among all the models.

## 4.2 Physical Measurements

The different physical measurement parameters *viz.*, body length (BL), height at wither (WH), heart girth (HG), paunch girth (PG) and cannon circumference (CC) were measured at 180 days of age in the 324 Black Bengal goats of the Terai and Hill zones of West Bengal; the means along with the SE and CV estimates of the measurements have been presented in Table 4.5.

As in the table, the mean BL of Black Bengal goats (pooled) at 180 days of age was obtained to be  $42.389 \pm 0.138$  cm. The measurement tallies well with the finding of Kumar *et al.* (loc. cit.), and Pattanaik & Mishra (1985). Lower BL in the Black Bengal goats were reported by Mukherjee *et al.* (1979), in Grey Bengal goats, by Chatterjee (1992). Higher BL were also recorded by Kumar and Singh (loc. cit.), Bhattacharya *et al.* (1984), and Patro & Mishra (1987) in BB x JP crosses, adult Black Bengal, and Ganjam goats, respectively.

**Table 4.5 : Means of the physical measurement parameters of Black Bengal goats (at 180 days of age) of Terai and Hill zones of West Bengal.**

Traits	No. of obs	Mean	SE	CV (%)
Body length (cm)	324	42.389	0.138	5.89
Height at wither (cm)	324	40.401	0.146	6.51
Heart girth (cm)	324	48.444	0.164	6.09
Paunch girth (cm)	324	56.164	0.203	6.49
Cannon circumference (cm)	324	6.012	0.042	12.45

As it appears in the Table 4.5, the mean height at wither (WH) was estimated to be  $40.401 \pm 0.146$  cm in the Black Bengal goats of Terai and Hill zones (pooled). The WH was observed to be lower than those reported by Mukherjee *et al.* (loc. cit.), Kumar and Singh (loc. cit.), Bhattacharya *et al.* (loc. cit.), Pattanaik and Mishra (loc. cit.) and Chatterjee (loc. cit.), in Black Bengal goats, Kumar and Singh (loc. cit.) in BB x JP goats, and Patro & Mishra (loc. cit.) in Ganjam goats, respectively.

The mean HG of the 324 goats at 180 days of age was obtained to be  $48.444 \pm 0.164$  cm (Table 4.5); the finding coincides well with the findings of Pattanaik and Mishra (loc. cit.) in Black Bengal goats, and Kumar & Singh (loc. cit.) in BB x JP goats. Lower measurements of HG in Black Bengal goats were obtained by Kumar and Singh (loc. cit.), and Chatterjee (loc. cit.). Higher HG in comparison to the present finding were reported by Mukherjee *et al.* (loc. cit.), in Grey Bengal, Bhattacharya *et al.* (loc. cit.), in Black Bengal, and Pattanaik and Mishra (loc. cit.) in Ganjam goats.

The mean PG of the 324 Black Bengal goats under field condition of Terai and Hill zones at 180 days of age was ascertained to be  $56.164 \pm 0.203$  cm with the CV of 6.49 per cent. Information on this physical trait is very limited, it being practically nil on the goats under field conditions. Kumar and Singh (loc. cit.) obtained a lower estimate of PG in both the Black Bengal and BB x JP goats.

The CC of the Black Bengal goats as in Table 4.5 was noted to be  $6.012 \pm 0.042$  cm with the higher CV of 12.45 per cent. Information on this physical trait measurement is also scanty. A higher value of CC of 7.680 cm was reported in Black Bengal x Ganjam goats by Mahapatra and Nayak (1996).

#### **4.2.1 Factors Considered to Affect Physical Measurements**

The data generated as physical measurement parameters from 324 Black Bengal goats at 180 days of age at the Terai and Hill zones were put for LS-analysis of variance as in Annex Table 2. Effectwise LS-means of the physical measurement traits have been presented in Table 4.6.

As in the table stated, highly significant ( $P < 0.01$ ) zonal variations of all the 5 physical measurement traits were observed. The Hill goats (Table 4.6) had

significantly higher values of all the physical measurement traits. Any information on this aspect of zonal variation could not be made available. This variation might be due to the fact that the Hill goats as compared to Terai were heavier at different ages (4.1.3.1) along with higher daily weight gain (4.1.3.2), and hence Hill goats were expected to gain higher physical dimensions also.

As it is apparent from the Annex Table 2 and Table 4.8, the effect of sex on the body measurement parameters of Black Bengal goats were found to be highly significant ( $P < 0.01$ ), the males bearing higher values in all the measurement traits. BL and HG were reported to be affected by sex as observed by Khan *et al.* (1992) in Black Bengal goats, Das *et al.* (1993), in Assam Hill and Assam Hill x Beetal goats, Singh (1998), in BB, BB x JP and BB x Beetal goats. WH and PG in the present study were also affected ( $P < 0.01$ ) by sex, the LS-means of males being higher than that of females. The findings of Khan and Sahni (*loc. cit.*) in Jamunapari goats, and Singh (*loc. cit.*) in BB, BB x JP and BB x Beetal goats support the present finding. Singh (1999), on the otherhand, did not find any appreciable sex variation of the PG in BB, BB x JP, and BB x Beetal goats. From the growth studies (4.1.3.1) it was observed that males being heavier at any given age under present investigation. Due to higher body weight and more body capacity, the males might have higher values of the body dimensional traits.

Pronounced ( $P < 0.01$ ) effect of litter size on all the physical measurement traits were observed in the present study (Annex Table 2 and Table 4.6). The kids born as singles were found to have highest body dimensional traits followed by the twins and triplets. Significant effect of litter size on body biometrics were also reported by Khan and Sahni (*loc. cit.*), and Singh (*loc. cit.*) in JP and BB, BB x JP and BB x Beetal goats, respectively, the findings being tallied well with the findings in the present investigation. This variation as noticed might be due to the differential body weight gain by the goats bearing variant litter size at 180 days of age.

Non-significant effect of parity of kidding of does (LS-ANOVA Table 2 and Table 4.6) were observed on BL, WH and HG measurements, the effect being significant for PG ( $P < 0.01$ ) and CC ( $P < 0.05$ ). The effectwise LS-means of BL, WH and HG did not vary significantly, though the LS-means of both the PG and CC at 2<sup>nd</sup>

**Table 4.6 : Effectwise LS-means of the physical measurement parameters of Black Bengal goats (at 180 days of age) of Terai and Hill zones of West Bengal.**

Effects and levels		Physical traits (cm)									
		Body length	± SE	Height at wither	± SE	Heart girth	± SE	Paunch girth	± SE	CC	± SE
Zone	T	42.050 <sup>b</sup>	0.182	39.746 <sup>b</sup>	0.177	47.950 <sup>b</sup>	0.219	55.072 <sup>b</sup>	0.253	5.892 <sup>b</sup>	0.043
	H	42.818 <sup>a</sup>	0.209	41.231 <sup>a</sup>	0.227	49.070 <sup>a</sup>	0.239	57.545 <sup>a</sup>	0.290	6.164 <sup>a</sup>	0.075
Sex	M	43.394 <sup>a</sup>	0.173	41.782 <sup>a</sup>	0.176	49.237 <sup>a</sup>	0.223	56.763 <sup>a</sup>	0.280	6.327 <sup>a</sup>	0.061
	F	41.363 <sup>b</sup>	0.182	39.119 <sup>b</sup>	0.180	47.708 <sup>b</sup>	0.225	55.607 <sup>b</sup>	0.285	5.720 <sup>b</sup>	0.047
Lt Sz	1	43.766 <sup>a</sup>	0.346	41.875 <sup>a</sup>	0.385	50.500 <sup>a</sup>	0.452	58.359 <sup>a</sup>	0.560	6.484 <sup>a</sup>	0.135
	2	42.261 <sup>b</sup>	0.155	40.232 <sup>b</sup>	0.160	48.175 <sup>b</sup>	0.171	55.943 <sup>b</sup>	0.208	5.957 <sup>b</sup>	0.040
	3	41.143 <sup>c</sup>	0.340	39.204 <sup>c</sup>	0.349	46.918 <sup>c</sup>	0.350	54.245 <sup>c</sup>	0.427	5.633 <sup>c</sup>	0.083
Pty Kid	1	41.440	0.495	40.560	0.527	48.160	0.586	55.280 <sup>b</sup>	0.709	5.880 <sup>b</sup>	0.146
	2	43.191	0.361	41.064	0.384	49.660	0.427	58.255 <sup>a</sup>	0.617	6.362 <sup>a</sup>	0.108
	3	42.386	0.264	40.239	0.281	48.511	0.312	56.273 <sup>b</sup>	0.378	6.028 <sup>b</sup>	0.079
	4	42.316	0.278	40.127	0.296	47.899	0.330	55.291 <sup>b</sup>	0.399	5.886 <sup>b</sup>	0.083
	5	42.510	0.353	40.408	0.376	48.347	0.418	56.000 <sup>b</sup>	0.507	5.969 <sup>b</sup>	0.106
	6	42.385	0.686	41.000	0.731	48.769	0.812	57.000 <sup>ab</sup>	0.983	6.115 <sup>ab</sup>	0.205
	7	41.222	0.583	39.722	0.621	47.611	0.690	54.889 <sup>b</sup>	0.836	5.778 <sup>b</sup>	0.174
	8	43.500	1.750	40.500	1.863	49.000	2.071	57.500 <sup>ab</sup>	2.507	6.000 <sup>ab</sup>	0.523
	9	44.000	1.428	42.000	1.521	49.000	1.691	56.333 <sup>ab</sup>	2.047	6.167 <sup>ab</sup>	0.427
Sn Bt	S	42.559	0.222	40.591	0.234	48.551 <sup>a</sup>	0.260	56.173 <sup>ab</sup>	0.321	6.051	0.067
	M	42.086	0.328	40.052	0.346	47.603 <sup>b</sup>	0.385	55.190 <sup>b</sup>	0.476	6.052	0.098
	W	42.360	0.212	40.374	0.223	48.698 <sup>a</sup>	0.249	56.561 <sup>a</sup>	0.367	5.960	0.064

Same alphabets in superscripts denote no significant differences at 5% level.

Note : The terms Lt Sz, Pty Kid and Sn Bt denote litter size, parity of kidding and season of birth respectively.

parity differed significantly with higher measurements. It is interesting to note that all the 5 physical measurements of goats born under the 2<sup>nd</sup> parity of kidding of the dam does were higher, and measurements of goats under other parity of dam's kidding did not follow any definite trend. The measurements under 8<sup>th</sup> and 9<sup>th</sup> parity had very meagre sample size to be considered. No supporting information could be made available on the aspect of parity effect of dam's kidding on the variabilities of PG and CC of the progeny kids (at such 6 months).

As in Annex Table 2 and Table 4.6, season of birth-effect was found to be statistically non-significant on the variations of BL, WH and CC measurements with the exception on HG and PG, where the effect was significant ( $P < 0.05$ ). The summer and winter born goats had higher body measurements (as well as higher body weight at 180 days of age as in Table 4.3) than those born in monsoon, the differences of LS-means of the former 2 being significantly ( $P < 0.05$ ) higher than the later one (monsoon) for the HG and PG measurements. Literature on this aspect are not available much. Seasonal effect on BL variation in the Black Bengal, Jamunapari and BB x JP goats were noted by Khan and Sahni (loc. cit), Singh (1998), and Singh (1999). Such seasonal effects on the HG and PG were reported by Singh (loc. cit) and Singh (loc. cit).

#### **4.2.2 Correlation-Regression Studies between Growth and Physical Measurement Traits**

Pearson correlation ( $r$ ) matrix between the paired parameters of growth, physical measurements, and between growth and physical measurements of the Black Bengal goats at the Terai and Hill zones of West Bengal were developed and ascertained as in Table 4.7.

As it appears in Table 4.7, all the growth parameters *viz.*, B wt, 30-D wt, 90-D wt and 180-D wt, and all the physical parameters *viz.*, BL, WH, HG, PG and CC were positively and highly significantly ( $P < 0.01$ ) correlated. Higher the body weight at the initial stage of animals, higher was the body weight at later age; higher the body weight at early age, higher was the attainment of physical measurements at 180 days of age, and higher the physical measurements at later life (180 days of age), also

higher was the body weight at the same (180 days) age (might be even after) in the Black Bengal goats under such field conditions at the Terai and Hill zones. Such studies are of academic and practical interests (for the farmers even) for planning to select goats for higher production.

Highly positive correlations of body weight were obtained with chest girth and paunch girth by Singh *et al.* (1979), with BL, HG and PG by Singh *et al.* (1987), and with BL and HG by Varada *et al.* (1997). Singh (1999) also obtained moderately high but positive correlation of body weight with physical measurement traits in the JP x BB and Beetal x BB crossbred goats. Majid *et al.* (1999) also reported highly positively correlations ( $P < 0.01$ ) of the chest girth and some other measurements with the body weight in Black Bengal goats. Mahapatra and Nayak (1990), on the other hand could find only WH to be correlated with body weight and not the other measurements including canon circumference (CC) in the BB x Ganjam crossbred goats of Orissa farm.

The present findings in the correlation matrix as in Table 4.7 have interesting observations that the physical measurements were highly positively correlated with the body weight at 180 days of age and even the CC being highly positively correlated with all the estimated parameters of growth and other physical measurements. Information in the aspect studied are scanty. Mahapatra and Nayak (*loc. cit*) of course, did not find any such appreciable correlations of CC with growth.

Both the stepwise and full model regression analyses based on partial correlation coefficients were used in order to select the predictor variables free from multicollinearity problems. The predictor variables incorporated in a step having highest value of adjusted  $R^2$  were identified as independent predictor variables to form the regression equation.

Partial regression coefficients as  $b_1$ ,  $b_2$ ,  $b_3$ ,  $b_4$  and  $b_5$  for  $x_1$  (BL),  $x_2$  (WH),  $x_3$  (HG),  $x_4$  (PG) and  $x_5$  (CC) on Y (180-D wt) were worked out and the results have been given in Table 4.8 along with constants,  $R^2$ , adj.  $R^2$  and standard errors of estimation values for both the stepwise and full model regressions. All the partial



**Table 4.8 : Stepwise and full model regression equations for prediction of body weight on the basis of various physical measurement parameters in Black Bengal goats.**

Equation No.	Dependent variable	Constant	Partial regression coefficients $\pm$ SE					R <sup>2</sup> (%)	adj. R <sup>2</sup> (%)	SE of the estimation
			b <sub>1</sub>	b <sub>2</sub>	b <sub>3</sub>	b <sub>4</sub>	b <sub>5</sub>			
Stepwise										
1	Y	-11.253	0.501 $\pm$ 0.016					86.7	75.2	0.721
2	Y	-12.915	0.297 $\pm$ 0.02	0.256 $\pm$ 0.02	-			91.9	84.4	0.573
3	Y	-14.243	0.167 $\pm$ 0.02	0.241 $\pm$ 0.015	-	0.132 $\pm$ 0.011		94.6	89.5	0.471
4	Y	-11.920	0.125 $\pm$ 0.02	0.191 $\pm$ 0.016	-	0.110 $\pm$ 0.01	0.453 $\pm$ 0.06	95.4	91.1	0.434
Full Model	Y	-12.037	0.12 $\pm$ 0.02	0.187 $\pm$ 0.016	0.027 $\pm$ 0.019	0.096 $\pm$ 0.014	0.445 $\pm$ 0.06	95.5	91.0	0.433

Note : All partial regression coefficients are significant at 1% level except the same for b<sub>3</sub> at full model equation.

b<sub>1</sub>, b<sub>2</sub>, b<sub>3</sub>, b<sub>4</sub> and b<sub>5</sub> are the partial regression coefficients of Y on body length (x<sub>1</sub>), wither height (x<sub>2</sub>), heart girth (x<sub>3</sub>), paunch girth (x<sub>4</sub>) and cannon circumference (x<sub>5</sub>).

Y is the body weight at 180 days of age.

regression coefficients ( $b_1$ ,  $b_2$ ,  $b_4$  &  $b_5$ ) except  $b_3$  were significant at 1% level in both the models.

From the stepwise model it be concluded that the BL, WH, PG and CC are the good predictor variables to estimate body weight at 180 days of age but not the HG. Inclusion of HG at full model regression equation reveals that adj.  $R^2$  value had been decreasing from its highest value at equation 4 in Table 4.8 which might be due to significant correlation of HG with other predictor variables already included in the equation 4. The equation 4, hence, can be accepted as best fitted regression model to predict the response variable 180-D wt.

Selection of goats on the basis of higher body weight is necessary to get animals to produce high. Under field conditions in absence of actual weighment tools, such prediction equations basing on physical measurements (which a farmer can easily generate) are to be depended upon to get animals of higher live weight. Information on this aspect are not much in hand, particularly for the goats under field conditions. Kumar & Singh (1983) developed such equations in Black Bengal goats in farm of UP bearing 76% accuracy with chest girth, 74% accuracy with BL and only 69% with WH. Varada *et al.* (1997) attempted body weight prediction taking heart girth, abdominal girth and body length on the equation in Black Bengal goats. The regression coefficients were obtained to be statistically non-significant and the equations were of low predictability.

Singh (2000) on the other hand, obtained 90% accuracy of predictions of body weight basing on BL, WH, HG and PG, the regression being highly significant in the Black Bengal goats under farm conditions of UP. The present finding (Prediction equation 4) with the field goats tally well with Singh (*loc. cit.*) with Black Bengal goats at farms.

### **4.3 Haemato-constituent Parameters**

Blood collected from 184 Black Bengal goats (of either sex) under the field conditions of the Terai and Hill zones at 6 months of age were used for estimation and

analysis of the 12 different haematological profiles and 5 serum trace minerals, the results of which are being presented and discussed as below :

#### **4.3.1 Haematological Profiles**

The results (means along with SE and CV%) of the 12 different haematological profiles in the 184 Black Bengal goats as randomly included under the present investigation, have been presented in Table 4.9.

Total Erythrocytic Count (TEC) of Black Bengal goats under the Terai and Hill zones (pooled) was estimated to be  $13.293 \pm 0.056$  m/cmm (Table 4.9). Higher values of TEC than the present finding were reported by Wintrobe (1933), in exotic goat (17.33 m/cmm), and Bhalia and Sharma (1966), in hilly goats (16.6 m/cmm). Lower TEC of 11.05 – 12.35 m/cmm were also reported by several workers (Gill & Mishra, 1972 in Beetal; Dey Sarkar, 1974, Patra, 1981, and Pyne *et al.*, 1982 in Black Bengal goats),

The mean Total Leucocytic Count (TLC) of Black Bengal goats under field conditions as in the Table 4.9 was obtained to be  $10.016 \pm 0.030$  th/cmm. The available literature on TLC values of goats is very limited particularly on such population of animals under the field condition. The present finding corroborated well with the finding of Pyne *et al.* (1982) in the Black Bengal goats. Ghosh *et al.* (1993), however, recorded lower values of TLC both under the deep litter and free range management systems.

As it transpires in Table 4.9, the mean Haemoglobin (Hb) concentration was noted to be  $10.333 \pm 0.073$  g/dl. The finding was in close conformity with Howladar and Huq (1997) in Black Bengal goats. Higher Hb values than the present finding were reported by Dey Sarkar (*loc. cit.*), Patra (*loc. cit.*) and Siddiqua *et al.* (1990) in Black Bengal goats; Okorie and Anugwa (1986), in Kano Brown; Popisil (1987) in Cameroon, and by Rastogi and Singh (1990), in Gaddi goats. Lower Hb content was also observed by Mondal (1995), and Das (1997), in Black Bengal goats.

The mean PCV per cent in the Black Bengal goats as in Table 4.9 was obtained to be  $31.261 \pm 0.316$ . Dey Sarkar (*loc. cit.*) and Patra (*loc. cit.*) reported

lower PCV in the same breed of goats, while a little higher PCV was also reported by Howladar and Huq (loc. cit.).

The MCV, MCH and MCHC of Black Bengal goats of Terai and Hill zones (pooled) were derived, the means as in Table 4.9 being  $23.440 \pm 0.165$  cu  $\mu$ ,  $7.765 \pm 0.035$  pg and  $33.316 \pm 0.189$  per cent, respectively. Relevant literature on these parameters on goat is very scanty, particularly with such number of animals under field condition. The MCV in the present finding tallies well with the finding of Patra (loc. cit.), but differs with Dey Sarkar (loc. cit.) who reported a higher value. Both the MCH and MCHC estimates in the present study were, however, observed to be lower than those reported by Dey Sarkar (loc. cit.) and Patra (loc. cit.) in the same breed.

As in the Table 4.9, the means of the Differential Leucocytic Counts (DLC) *i.e.* the mean Neutrophils, Lymphocytes, Monocytes, Eosinophils and Basophils in the Black Bengal goats under the present investigation were estimated to be  $35.701 \pm 0.209$ ,  $58.419 \pm 0.165$ ,  $2.397 \pm 0.071$ ,  $2.935 \pm 0.089$  and  $0.576 \pm 0.045$  per cent, respectively. Literature on such DLC of goats could not be made available much. Lower Neutrophils (%) were reported by Pyne *et al.* (loc. cit.) and Ghosh *et al.* (loc. cit.). The Lymphocytes (%) were obtained to be lower in the present Black Bengal goats than those reported by Pyne *et al.* (loc. cit.), and Ghosh *et al.* (loc. cit.). Monocytes higher and monocytes lower than the present findings in Black Bengal goats were reported by Pyne *et al.* (loc. cit.), and Ghosh *et al.* (loc. cit.), respectively. Lower levels of both Eosinophils and Basophils were found by Pyne *et al.* (loc. cit.) in Black Bengal goats. A higher level of Basophils was also reported by Ghosh *et al.* (loc. cit.). All the haematological parameters were well within the normal physiological range of goats, even under the free range systems of management in the field conditions of Terai and Hill zones.

#### **4.3.1.1 Factors Considered to Affect Haematological Profiles**

Three factors, *viz.*, zone, sex and season of collection of blood samples from the 184 Black Bengal goats were considered to affect the haematological profiles and the effects causing any significant variation of the estimated parameters were tested through LS-ANOVA as in Annex Table 3; the effectwise LS-means of various

**Table 4.9 : Means of the haematological parameters of Black Bengal goats of Terai and Hill zones of West Bengal.**

Parameters	No. of obs	Mean	SE	CV (%)
TEC (m/cmm)	184	13.293	0.056	5.72
TLC (th/cmm)	184	10.016	0.030	4.08
Neutrophils (%)	184	35.701	0.209	7.94
Lymphocytes (%)	184	58.419	0.165	3.84
Monocytes (%)	184	2.397	0.071	40.46
Eosinophils (%)	184	2.935	0.089	41.46
Basophils (%)	184	0.576	0.045	104.98
Hb (g/dl)	184	10.333	0.073	9.61
PCV (%)	184	31.261	0.316	13.73
MCV (cu $\mu$ )	184	23.440	0.165	9.53
MCH (pg)	184	7.765	0.035	6.07
MCHC (%)	184	33.316	0.189	7.73

haematological profiles have also been presented in Table 4.10. The literature on the variability studies of the blood parameters due to causes stated is very scanty. Hence the results of the present investigation may add some basic informations on haematological profiles of the Black Bengal goats at Terai and Hill zones of West Bengal.

Zonal variation of TEC was found to be highly significant ( $P < 0.01$ ), the TEC being significantly higher in Hill goats ( $13.651 \pm 0.071$  m/cmm) than that of Terai ( $12.951 \pm 0.070$  m/cmm). TEC was observed to be rapidly increased when goats were exposed to high altitude (Validixia and Othensmeyer, 1963). Significant ( $P < 0.05$ ) zonal variation of TLC was also observed in the present investigation, the value, as like TEC, being higher in Hill goats ( $10.076 \pm 0.043$  th/cmm) in comparison to that of Terai goats ( $9.958 \pm 0.042$  th/cmm). Pronounced ( $P < 0.01$ ) zonal variation of Hb content was recorded in the present study, LS-means being significantly higher in Hill goats ( $10.726 \pm 0.097$  g/dl) than in Terai goats ( $9.956 \pm 0.095$  g/dl). Increase of Hb content after exposure to high altitude was reported by Validixia and Othensmeyer (loc. cit.). Significant variation of Hb content due to zone effect was also observed by Mondal (loc. cit.), and Das (loc. cit.). The zonal variation of PCV (as in Annex Table 3 and Table 4.10) was highly significant ( $P < 0.01$ ), the Hill goats having significantly higher PCV ( $32.467 \pm 0.436$ ) than that of Terai goats ( $30.106 \pm 0.427$ ). Relationships have been observed to exist between PCV and altitude (Validixia and Othensmeyer, loc. cit.). The MCH as well as Eosinophils were also found to vary significantly ( $P < 0.05$ ) between the zones, both the values being higher in Hill goats. Among other haematological parameters, Neutrophils, Monocytes and MCHC were found to be non-significantly higher in Terai zone; on the other hand, Lymphocytes and MCV values were marginally but non-significantly higher in the Hill zone.

Remarkable variation in respect to the altitude between the zones as in the present study, exists. The Hill zone being situated at a higher altitude is supposed to have lower Oxygen tension. To cope up with the situation and also for the fulfillment of physiological demands, the Hill goats might have produced more RBC which was reflected in the higher Hb content as compared to the goats of Terai zone. Since TEC, Hb and PCV are highly correlated parameters, obviously the PCV is expected to show

**Table 4.10 : Effectwise LS-means of the haematological parameters of Black Bengal goats of Terai and Hill zones of West Bengal.**

Effects and levels	TEC (m/cmm) ± SE	TLC (th/cmm) ± SE	Neutrophils (%) ± SE	Lymphocytes (%) ± SE	Mono-cytes (%) ± SE	Eosino-phils (%) ± SE	Baso-phils (%) ± SE	Hb (g/dl) ± SE	PCV (%) ± SE	MCV (cu μ) ± SE	MCH (pg) ± SE	MCHC (%) ± SE
<b>Zone</b>												
T	12.951 <sup>b</sup>	9.958 <sup>b</sup>	35.957	58.245	2.511	2.755 <sup>b</sup>	0.543	9.956 <sup>b</sup>	30.106 <sup>b</sup>	23.185	7.688 <sup>b</sup>	33.384
	0.070	0.042	0.292	0.232	0.100	0.124	0.062	0.095	0.427	0.229	0.048	0.266
H	13.651 <sup>a</sup>	10.076 <sup>a</sup>	35.433	58.600	2.278	3.122 <sup>a</sup>	0.611	10.726 <sup>a</sup>	32.467 <sup>a</sup>	23.705	7.845 <sup>a</sup>	33.245
	0.071	0.043	0.298	0.237	0.102	0.127	0.064	0.097	0.436	0.235	0.049	0.272
<b>Sex</b>												
M	13.457 <sup>a</sup>	10.051	35.582	58.663	2.327	2.949	0.520	10.446	31.765 <sup>a</sup>	23.546	7.756	33.123
	0.075	0.041	0.287	0.226	0.098	0.123	0.061	0.100	0.431	0.226	0.048	0.260
F	13.107 <sup>b</sup>	9.976	35.837	58.140	2.477	2.919	0.640	10.203	30.686 <sup>b</sup>	23.318	7.775	33.536
	0.080	0.044	0.306	0.241	0.105	0.132	0.065	0.107	0.460	0.241	0.051	0.278
<b>Season</b>												
S	13.203	9.930 <sup>b</sup>	35.857	58.587	2.381	2.619 <sup>b</sup>	0.587	10.388	31.413	23.710	7.852	33.340
	0.096	0.050	0.358	0.284	0.122	0.151	0.077	0.126	0.543	0.282	0.059	0.326
Ms	13.266	9.949 <sup>b</sup>	35.831	58.373	2.237	3.051 <sup>a</sup>	0.593	10.251	30.966	23.262	7.723	33.362
	0.099	0.052	0.370	0.293	0.126	0.156	0.079	0.130	0.561	0.291	0.061	0.337
W	13.412	10.166 <sup>a</sup>	35.419	58.290	2.565	3.145 <sup>a</sup>	0.548	10.360	31.387	23.334	7.716	33.248
	0.097	0.050	0.361	0.286	0.123	0.153	0.077	0.127	0.548	0.284	0.060	0.329

Same alphabets in superscripts denote no significant differences at 5% level.

higher value in Hill goats as in the present findings. The higher values of TLC and Eosinophils might be due to the differential environmental stress prevailing in the 2 zones.

As in the Annex Table 3, the effect of sex on TEC in the Black Bengal goats was found to be highly significant ( $P < 0.01$ ), the males bearing higher TEC ( $13.457 \pm 0.075$  m/cmm) than that of the females ( $13.107 \pm 0.80$  m/cmm). Highly significant variation of TEC due to sex was reported by Das *et al.* (1992), in Assam Hill goats. Significant sex variation of PCV was also observed in the present investigation, the Hill goats having higher PCV than the Terai goats ( $31.765 \pm 0.431\%$  vs  $30.686 \pm 0.460\%$ ). Similar sex effect on variation in PCV was also reported by Das *et al.* (loc. cit.). Marginally (non-significant) higher values of TLC, Lymphocytes, Eosinophils, Hb and MCV were observed in the Hill goats, while the Neutrophils, Monocytes, Basophils, MCH and MCHC were non-significantly higher in the Terai goats. The variation of Hb and MCV due to sex were, however, reported to be significant (Das *et al.*, loc. cit.) in Black Bengal goats.

The effect of season of collection of blood on various haematological profiles were also tested through the LS-ANOVA as in the Annex Table 3, and the season-effectwise LS-means of the profiles have been given in Table 4.10. Though the TEC was observed to be marginally higher in winter ( $13.412 \pm 0.097$  m/cmm) than in monsoon ( $13.266 \pm 0.099$  m/cmm) and summer ( $13.203 \pm 0.096$  m/cmm), the effectwise LS-means did not differ significantly one from other. Howladar and Huq (1997) also observed such non appreciable variation of TEC due to season in the same breed of goats. The TLC, on the other hand, was noted to be affected significantly ( $P < 0.01$ ) by season, highest TLC was found in winter ( $10.166 \pm 0.050$  th/cmm), followed by monsoon ( $9.947 \pm 0.052$  th/cmm) and summer ( $9.930 \pm 0.050$  th/cmm). Season had also influenced ( $P < 0.05$ ) the Eosinophil count in Black Bengal goats at Terai and Hill zones, significantly lower count being observed in summer ( $2.619 \pm 0.151\%$ ) than those in winter ( $3.145 \pm 0.153\%$ ) and monsoon ( $3.051 \pm 0.156\%$ ). Marginally higher values of Neutrophils, Lymphocytes, PCV, MCV and MCH contents were obtained in summer in comparison to those in other 2 seasons. On the other hand, marginally higher contents of Hb and Monocytes in winter, and

Basophils and MCHC in monsoon were noted in the present investigation. Non appreciable variations of Hb and PCV due to season of collection were also reported by Howladar and Huq (loc. cit.).

Available literature in respect to the seasonal variation on various haematological profiles, especially under field condition are very scanty. Most of the parameters excepting TLC and Eosinophils were observed to be unaffected (significantly) by season. Howladar and Huq (loc. cit.) were also of the same opinion in respect to Hb and PCV. The significant variation of TLC and Eosinophils might be due the physiological adjustment of animals against different environmental factors, especially the climatic stress.

The haematological studies have great importance to ascertain growth, metabolic status and physiological normalities of the animals which are supposed to have impact on production potentialities of animals. It is therefore suggested to undertake extensive studies on different haematological profiles under different agroclimatic zones of West Bengal along with factors causing variations, before coming to a conclusion on their impact on production potentialities of animals and selection of better animals.

### **4.3.2 Serum Trace Minerals**

A number of 5 serum trace minerals *viz.* Iron, Copper, Zinc, Manganese and Cobalt, were estimated taking blood samples from the 184 Black Bengal goats at 6 months of age of Terai and Hill zones and the means along with SE and CV% of these elements have been presented in Table 4.11; the LS-ANOVA for factors (zone, sex and season of collection) considered to affect trace minerals levels as well as the effectwise LS-means of the trace minerals have been given in Annex Table 4 and Table 4.12, respectively.

#### **4.3.2.1 Iron (Fe)**

The mean serum Iron level in the Black Bengal goats of Terai and Hill zones (pooled) was estimated to be  $13.219 \pm 0.288$   $\mu\text{g/ml}$ . The value coincides with the finding of Mondal (1995), in Black Bengal goats of Hill zone. Lower serum Fe

concentrations were reported by Wanner and Boss (1978), and Wojcik *et al.* (1986) in the exotic goats, and Biswas (1993) and Das (1997), in Black Bengal goats.

The present finding revealed that the zone had significantly influenced the serum Fe concentration in Black Bengal goats, the content being significantly ( $P < 0.01$ ) higher in Hill goats ( $13.963 \pm 0.406 \mu\text{g/ml}$ ) than that of the goats of Terai zone ( $12.506 \pm 0.398 \mu\text{g/ml}$ ). Similar trend of zone-effect on the serum Fe were reported in Black Bengal goats by Mondal (loc. cit.) and Das (loc. cit.), though the variation was not statistically significant, and also the population size taken was smaller in case of former. Fe level in herbage depends on plant species (Ramirez *et al.*, 2001), and also the soil type, acid soils favouring plant higher uptake of Fe (McDowell, 1992). Low soil pH of the Hill zone and high Fe level in the Hill grazing plants might be the reasons of higher Fe concentration in goats' blood. Hill goats acquire momentum of higher Fe content in blood to have better physical status leading to subsequent higher growth and production.

As it transpires from Tables stated, non-significantly higher serum Fe content was observed in males than that of females. Information on the sexwise variation of the element could not be made available. The present finding indicated that sex did not influence the Fe level in Black Bengal goats under Terai and Hill zones of West Bengal.

As per Table 4.12 the serum Fe concentration was observed to be highest in winter ( $13.590 \pm 0.499$ ) followed by monsoon ( $13.043 \pm 0.511 \mu\text{g/ml}$ ) and summer ( $13.013 \pm 0.495 \mu\text{g/ml}$ ), the variations, of course, were not statistically significant. Nazki and Rattan (1990), and Bhattacharya *et al.* (1996) also obtained higher ( $P < 0.01$ ) level of serum Fe both in sheep and goat in winter. The increased level of serum Fe during winter months might be due to the increased number of circulating RBC owing to stimulating effect of corticosteroids and thyroxine on erythropoiesis. The exposure to cold stress resulted in higher levels of corticosteroides, thereby increasing the erythropoiesis, which in turn caused the elevation in Blood Fe level (Nazki and Rattan, 1990).

**Table 4.11 : Means of the serum trace minerals of Black Bengal goats of Terai and Hill zones of West Bengal.**

Parameters	No. of obs	Mean	SE	CV (%)
Iron ( $\mu\text{g/ml}$ )	184	13.219	0.288	29.60
Copper ( $\mu\text{g/ml}$ )	184	1.295	0.072	75.75
Zinc ( $\mu\text{g/ml}$ )	184	1.263	0.044	47.71
Manganese ( $\mu\text{g/ml}$ )	184	1.165	0.061	71.33
Cobalt ( $\mu\text{g/ml}$ )	184	0.328	0.027	112.50

**Table 4.12 : Effectwise LS-means of serum trace minerals of Black Bengal goats of Terai and Hill zones of West Bengal.**

Effects and levels		Serum trace minerals ( $\mu\text{g/ml}$ )									
		Iron	$\pm$ SE	Copper	$\pm$ SE	Zinc	$\pm$ SE	Manganese	$\pm$ SE	Cobalt	$\pm$ SE
Zone	T	12.506 <sup>b</sup>	0.398	1.159 <sup>b</sup>	0.100	1.339 <sup>a</sup>	0.062	1.190	0.086	0.362	0.038
	H	13.963 <sup>a</sup>	0.406	1.437 <sup>a</sup>	0.103	1.183 <sup>b</sup>	0.063	1.139	0.088	0.293	0.039
Sex	M	13.311	0.396	1.259	0.099	1.254	0.061	1.147	0.084	0.262 <sup>b</sup>	0.037
	F	13.114	0.423	1.336	0.106	1.273	0.065	1.186	0.090	0.404 <sup>a</sup>	0.039
Season	S	13.013	0.495	1.247	0.124	1.192 <sup>b</sup>	0.076	1.108	0.105	0.330	0.047
	Ms	13.043	0.511	1.222	0.128	1.198 <sup>b</sup>	0.780	1.141	0.109	0.282	0.048
	W	13.590	0.499	1.412	0.125	1.396 <sup>a</sup>	0.760	1.245	0.106	0.369	0.047

Same alphabets in superscripts denote no significant differences at 5% level.

#### 4.3.2.2 Copper (Cu)

As it appears in Table 4.11, the mean Cu level in the serum of Black Bengal goats at 6 months of age was estimated to be  $1.295 \pm 0.072$   $\mu\text{g/ml}$ . The present finding was in close conformity with those of Mondal (loc. cit.) and Bhattacharya *et al.* (1996) in Black Bengal and Assam local goats, respectively. A Cu level higher than the present estimate was reported by Das *et al.* (loc. cit.) in Black Bengal and by Grag *et al.* (1988) in Botswana goats. Nickert *et al.* (1990), of course, reported a little lower Cu level in the Angora goats.

Significant (at 5% level) variation in the Cu level of blood serum due to zone effect (Annex Table 4) was observed in the present study, the estimate being significantly higher in Hill goats ( $1.437 \pm 0.103$   $\mu\text{g/ml}$ ) than in the Terai goats ( $1.159 \pm 0.100$   $\mu\text{g/ml}$ ) as in Table 4.12. Such significant zonal variation was also reported by Mondal (loc. cit.) and Das (loc. cit.) in Black Bengal goats. Cu concentration in blood of animals depends on the available Cu in plant crops which in turn depends on soil factors, plant factors (species, stage of maturity, yield, crop management), climate and soil pH, the Cu level being higher in acid soil (McDowell, 1992). The lower level of Cu in the Terai goats was possibly due to deficiency of Cu in grazing plants, higher soil pH, malabsorption and interference in the Cu uptake and inefficiency of liver for the conversion of copper-globulin binding from copper-albumin binding therein (Grag *et al.*, loc. cit.).

Variation in the serum Cu level due to sex was also found to be non-significant (Annex Table 4), females having marginally higher value.

Non-significantly higher estimate of Cu was obtained in winter, the level being lowest in monsoon. Significantly higher Cu levels in winter were reported by Nazki and Rattan (loc. cit.) in sheep, and Bhattacharya *et al.* (loc. cit.) in Assam local goats. The increased level of Cu in winter might be due to the fact that Cu is an essential micronutrient for incorporation of iron in haem and formation of haemoglobin. In winter, erythropoiesis is more resulting in corresponding increase in blood Cu concentration (Bhattacharya *et al.*, 1996).

#### 4.3.2.3 Zinc (Zn)

Table 4.11 reveals that the mean Zinc (Zn) content in the blood of Black Bengal under field condition of Terai and Hill zones (pooled) was  $1.263 \pm 0.044$   $\mu\text{g/ml}$ . The finding was in close conformity with that of Mondal (1995), in Black Bengal goats. Higher concentrations of Zn were obtained by Reuter and Bowden (1987), in Angora goats and Das *et al.* (1997), in Black Bengal goats. Zn levels lower than the present finding were observed by Nickert *et al.* (1990), in Angora goats, McDowell *et al.* (1991) in exotic goats, Sarkar *et al.* (1994), in Black Bengal goats, and Bhattacharya *et al.* (1996) in Assam local goats.

As per zonal variability study, the present finding indicated the zone to have significant ( $P < 0.05$ ) impact (Annex Table 4) on serum Zn level in the Black Bengal goats under the present investigation. Zn content being higher<sup>in</sup> Terai goats ( $1.339 \pm 0.062$   $\mu\text{g/ml}$ ) than the Hill goats ( $1.183 \pm 0.063$   $\mu\text{g/ml}$ ). Similar zonal variation in the Zn content in blood serum of Black Bengal goats were reported by Mondal (loc. cit.) and Das (loc. cit.). The lower level of serum Zn in Hill zone as compared to Terai might be due to less amount of this element in the soils and grazing plants owing to higher soil erosion and drainage. Some other factors might be involved for such lower Zn content like status and pH of soil, maturity of plants, endo-parasitism, malnutrition, mineral interactions, etc.

As in Table 4.12, marginally higher level of serum Zn was noted in Black Bengal females, the variations, of course being non-significant statistically. Researches in this aspect are not much. Haldar *et al.* (1998), observed high serum Zn in the Barbari males than females.

The concentration of Zn in the present study varied significantly ( $P < 0.05$ ) among the seasons (Annex Table 4) the value being highest in winter ( $1.396 \pm 0.076$   $\mu\text{g/ml}$ ) followed by monsoon ( $1.198 \pm 0.078$   $\mu\text{g/ml}$ ) and then summer ( $1.192 \pm 0.076$   $\mu\text{g/ml}$ ) [Table 4.12]. Nazki and Rattan (loc. cit.), and Bhattacharya *et al.* (loc. cit.) reported non-significant increase of the element during winter as compared to other seasons. The increased level of Zn in winter might be due to its higher availability in the diet and general increase in metabolic activity during winter, being affected by several enzymes having Zn as their functional component.

#### 4.3.2.4 Manganese (Mn)

The mean Mn level in the blood serum of 184 Black Bengal goats under the Terai and Hill zones (pooled) of West Bengal was estimated to be  $1.165 \pm 0.061$   $\mu\text{g/ml}$  (Table 4.11). Lower values with a wider range of 0.07 to 1.12  $\mu\text{g/ml}$  of the element were reported by Biswas (1993), Mondal (loc. cit.) and Das (loc. cit.) in Black Bengal goats under different zones of West Bengal, and by Uranium and Feliciano-Silva in the exotic goats (1984).

Influence of zone on the serum Mn level was tested by LS-ANOVA (Annex Table 4). The variation was, however, found to be statistically non-significant, though the Terai goats contained little higher Mn level ( $1.190 \pm 0.086$   $\mu\text{g/ml}$ ) to that of Hill goats ( $1.139 \pm 0.088$   $\mu\text{g/ml}$ ), the trend supporting the finding of Mondal (loc. cit.). The Black Bengal goats of Red and Laterite, and New Alluvial zones of West Bengal also differed in the element (Mn) content in blood serum, according to Das (loc. cit.). Inadequate mineral content in the soil and grazing plants, maturity of plants, animal parasitism, etc. might be the complexed factors responsible for lowering the Mn level in Hill goats as under the present investigation.

As in Table 4.12, non-significantly higher level of serum Mn was obtained in female Black Bengal goats than that of males, the effect obviously not being pronounced. Such sexwise study on the element is scanty except Khan *et al.* (1995), who reported significant variation of the element in liver of male and female goats from Alabama.

A higher level of serum Mn though not statistically significant (Annex Table 4 and Table 4.12), was ascertained in winter in comparison to other 2 seasons. Relevant literature on such variation was not available. A comparatively higher value in winter suggested increased metabolic need of the animal in cold stress.

#### 4.3.2.5 Cobalt (Co)

The mean serum Co in the Black Bengal goats as in Table 4.11 was estimated to be  $0.328 \pm 0.027$   $\mu\text{g/ml}$ , the value being even non-detectable in some samples. Literature on Co content in any breed of goat could not be made available, though the

trace mineral's presence is essentially needed for metabolism, vitamin synthesis of animals.

Like other 4 serum trace elements, Co was also studied for variation due to various effects (Table 4.12). Non-significant existence of zonal variation on the element was observed in the present finding, the value being higher in Terai goats ( $0.362 \pm 0.038 \mu\text{g/ml}$ ) than in the Hill goats ( $0.293 \pm 0.039 \mu\text{g/ml}$ ). Rainfall, soil status, plant species and stage of maturity etc. are some of the causes of variation in Co content of plants (McDowell, 1992) and these in turn might be the causes of higher serum Co concentration in the Terai goats.

The variation of serum Co value between the sexes was found to be significant ( $P < 0.05$ ) as in the Annex Table 4, the females having higher value ( $0.404 \pm 0.039 \mu\text{g/ml}$ ) than male goats ( $0.262 \pm 0.037 \mu\text{g/ml}$ ) as in Table 4.12. No literature could be made available on such variation of Co content in goat or in any other livestock species. Marginally higher value of serum Co during winter season was obtained in the present study which might be due to the soil-plant-animal interactions as discussed earlier.

The trace amount of Fe, Cu, Zn, Mn and Co in the blood are considered to exert immense physiological importance due to their involvement in number of enzyme systems acting at the cellular level. Thus, it is suggested that apart from other factors, proper growth, production and reproduction of goats can only be expected provided the goats have an access to requisite quantity of trace minerals in their diet in assimilable form. The soil-plant-animal inter-relationship is intimately concerned with proper availability of trace minerals to the animals.

# CHAPTER 5

## SUMMARY AND CONCLUSION

# **SUMMARY AND CONCLUSION**

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With a view of generating various information on the performances of the precious Black Bengal goats, especially being reared under the field condition of different agroclimatic zones of West Bengal, the present research investigation was limited at the Terai and Hill zones covering the periods 1999 and 2000.

Observations were taken from the Black Bengal goats at the farmers' door levels from 4 randomly selected villages of each zone over the 3 different seasons of the year. The 4 aspects of goat performance studied were production performance, physical measurements, haematological profiles and serum trace mineral contents.

Initially, 378 kids born normally under the 213 does were included in the present study, and the kids were kept under observation at the farmers level for 180 days (6 months) period. Body weight were recorded at 0-day, 30-day, 90-day and 180-day age, while the 5 different physical measurement parameters *viz.*, body length, wither height, heart girth, paunch girth and cannon circumference on the 324 goats at 180 days were measured.

Five factors (as effects) *viz.* zone, sex, litter-size, parity of kidding (of dam-does), and season of birth, were considered to affect the production and physical measurement parameters. Twelve different haematological and 5 different serum trace mineral parameters were ascertained following standard methods on the blood of 184 apparently healthy Black Bengal goats at 180 days of age. The data generated on different parameters studied were statistically treated, analysed and interpreted following appropriate models and methods.

The research findings may be summarized and concluded as below :

## **I. Production Performance**

### **1. The Litter Size**

- (i) The average litter-size in the 213 Black Bengal goats of the Terai and Hill zones (pooled) was obtained to be  $1.769 \pm 0.611$

- (ii) Zone and parity of kidding were found to cause appreciable variation in the litter-size, it being higher at the Terai zone and increased upto 5<sup>th</sup> parity.

## 2. Birth Weight

- (i) The mean birth weight of the 378 Black Bengal kids was estimated to be  $1.141 \pm 0.011$  kg, the weight being higher in comparison to the findings of many other workers.
- (ii) Zone, sex, litter-size and parity caused significant ( $P < 0.01$ ) variations of the birth weight; Hill kids, male kids, singles (then twins over triplets) had higher ( $P < 0.01$ ) LS-means. Summer born kids had higher birth weight though not statistically significant. Parity of birth had significant effect ( $P < 0.05$ ), the LS-means bearing no definite trend.

## 3. Growth

- (i) The means of the 30-day weight, 90-day weight and the 180-day weight of Black Bengal goats of the Terai and Hill zones (pooled), were estimated to be  $3.629 \pm 0.036$  kg,  $6.418 \pm 0.052$  kg and  $9.997 \pm 0.080$  kg, respectively, the weight gain being higher than the findings of many other workers.
- (ii) Zone, sex and litter-size caused variations ( $P < 0.01$ ) and also the parity ( $P < 0.05$ ) on the 3 growth parameters, the effect of season (of birth) being non-significant. The Hill born kids, the male kids and the singles (then the twins) were heavier ( $P < 0.01$ ) at all the 3 stages of growth. The parity effect to cause variations was significant at  $P < 0.05$  for the 90-day weight and 180-day weight. Season of birth did not show any appreciable effect to cause variation of growth parameters up to 180 days of age.

## 4. Growth Rate

- (i) The mean growth rate as the daily average weight gain. of Black Bengal kids were 82.93 g, 46.48 g, 39.77 g and 49.20 g at the 0-30 day, 31-90 day, 91-180 day and 0-180 days of age, respectively.

- (ii) Zone, sex and litter size had significant ( $P<0.01$ ) effects to cause variations in the growth rate at all the stages up to 180 days of age. The Hill kids, the males, and the singles (then twins) had higher ( $P<0.01$ ) growth rates.
- (iii) Out of the 5 growth-curve models fitted to predict growth of the Black Bengal goats at any given age of life, the quadratic model be accepted as the best fitted curve.

## II. Physical Measurements

1. The means of the 5 different physical measurement parameters *viz.* body length, wither height, heart girth, paunch girth and cannon circumference, as measured on the 324 Black Bengal goats of Terai and Hill zones at 180 days of age were  $42.389 \pm 0.138$ ,  $40.401 \pm 0.146$ ,  $48.444 \pm 0.164$ ,  $56.164 \pm 0.203$  and  $6.012 \pm 0.042$  cm, respectively.
2. Zone, sex and litter size caused variations significantly ( $P<0.01$ ) of all the 5 measurements, the Hill kids, the males and the singles (then the twins) having significantly higher LS-means. Season of birth affected only heart girth and paunch girth, the monsoon births having higher ( $P<0.01$ ) LS-means. The parity-effects were observed to be significant ( $P<0.05$ ) for paunch girth and cannon circumference, though no definite trend was established.

## Correlation and Regression studies

1. Correlations between growth and physical measurement parameters as estimated on the Black Bengal goats were positive and highly significant ( $P<0.01$ ).
2. Both the stepwise and full model regression analysis made for regression equations to predict body weight at 180 days of age basing on the physical measurements, indicated the body length, wither height, paunch girth and cannon circumference would be the good predictor variables to be used in equation with 91 per cent accuracy.

### III. Haematological Profiles

1. Twelve different haematological parameters were estimated on 184 Black Bengal goats at 180 days of age. The mean TEC, TLC, Hb and PCV were obtained to be  $13.293 \pm 0.056$  m/cmm,  $10.016 \pm 0.030$  /cmm,  $10.333 \pm 0.073$  g/dl and  $31.261 \pm 0.316$  per cent, respectively. The MCV, MCH and MCHC were estimated to be  $23.440 \pm 0.165$  cu $\mu$ ,  $7.765 \pm 0.035$  pg and  $33.316 \pm 0.189$  per cent, respectively. The percentage distribution of the Leucocytes were obtained to be  $35.701 \pm 0.209$ ,  $58.419 \pm 0.165$ ,  $2.397 \pm 0.071$ ,  $2.935 \pm 0.089$  and  $0.576 \pm 0.045$  for Neutrophils, Lymphocytes, Monocytes, Eosinophils and Basophils, respectively.
2. Zone variations were significant for TEC, Hb, PCV ( $P < 0.01$ ) and TLC, Eosinophils and MCH ( $P < 0.05$ ), these being higher for the Hill goats. The male goats were significantly superior in respect to TEC and PCV contents. The TLC and Eosinophils in goats were observed to be significantly higher during winter as compared to monsoon and summer.

### IV. Serum Trace Minerals

1. Five serum trace minerals (Iron, Copper, Zinc, Manganese and Cobalt) were estimated following standard methods on the 184 Black Bengal goats of Terai and Hill zones (pooled), the mean Fe, Cu, Zn, Mn and Co being obtained to be  $13.219 \pm 0.288$ ,  $1.295 \pm 0.072$ ,  $1.263 \pm 0.044$ ,  $1.165 \pm 0.061$  and  $0.328 \pm 0.027$   $\mu$ g/ml, respectively.
  2. Zonal variations were significant for the Fe, Cu and Zn contents, the LS-means for Fe and Cu being significantly higher for Hill goats, and the Zn being higher for Terai goats. Sex of goats did not have any appreciable effect on the trace minerals except on Cobalt (Co), it being higher in the females. The season (of collection) also did not influence the trace minerals except Zn, the LS-means of it being significantly higher in winter than summer and monsoon.
- The present findings on the production, physical measurements and haematoconstituent profiles revealed some interesting information of practical

as well as academic importance of Black Bengal goats of Terai and Hill zones; such information are lacking so far.

- The Hill Black Bengal goats have expressed most of the production performances being higher, the most haematoconstituent profiles (TEC, TLC, Eosinophils, Hb and PCV) concerning blood cells, and trace minerals concerning blood serum(*viz.* Iron and Copper) logically are also higher in Hill Black Bengal goats than the Terai goats. The physical measurement characteristics were also found to show similar trend. These findings may lead to conclude that the Hill Black Bengal goats have assumed the separate genotypic identity (to be Hill strain of Black Bengal goats) by dint of long stay in the particular zone.
- Higher body weight gains of Black Bengal goats upto 180 days of age at both the zones have been found in comparison to the same breed in other locations as per the available literatures. This may be due to variant soil-plant-animal relations, agroclimates, green availabilities and other associated factors.
- Considering litter weight and economic returns, the triplet producing does may be favoured for selection, provided the mothers as well as the triplet kids are better cared for from the initial stage of life.
- Prediction of body weight from different body measurement parameters on the basis of regression equations as developed in the present investigation would be of much relevance in absence of weighment tools especially under field condition.
- The growth curve with quadratic model has been found to be best fitted curve for predicting body weight at any given age in Black Bengal goats.

# CHAPTER-6

## FUTURE SCOPE OF RESEARCH

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- Black Bengal goat, the precious animal of West Bengal is yielding quality meat and skin. Taking the breed outside the state as the good genetic resource, researches particularly on crossbreeding to stabilize the high meat quality genes had been going on. It is high time, if not late, the breed to be characterized, conserved and improved.
- The findings of the present study would undoubtedly add some basic information on the Black Bengal goat in West Bengal under the field condition of Terai and Hill zones, which be exploited further through future researches for discrimination and stabilization of characters and also be extended on Black Bengal goats of other agroclimatic zones of West Bengal.
- Considering the better performance, the adaptability and performance studies of Hill goats in other agroclimatic zones may also be explored.
- Extensive studies on haemato-biochemical parameters of Black Bengal goats under field condition need to be undertaken to ascertain growth, reproduction, metabolic status and physiological functioning of goats.

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**ANNEXURE**

**Annex Table 1 : Least Square Analysis of Variance of the production performance parameters of Black Bengal goats – effectwise.**

Effect	Growth traits							
	Birth weight		30 day weight		90 day weight		180 day weight	
Source	df	MS	df	MS	df	MS	df	MS
Zone	1	4.749**	1	27.936**	1	35.590**	1	77.921**
Error	376	0.033	370	0.408	365	0.885	322	1.852
Sex	1	1.719**	1	15.116**	1	36.852**	1	124.949**
Error	376	0.041	370	0.443	365	0.882	322	1.706
Lt Sz	2	1.680**	2	12.033**	2	24.485**	2	46.343**
Error	375	0.074	369	0.420	364	0.851	321	1.812
Pty Kid	8	0.169*	8	0.918	8	2.100*	8	4.271*
Error	369	0.043	363	0.473	358	0.955	315	2.032
Sn Bt	2	0.009	2	0.374	2	0.848	2	0.295
Error	375	0.046	369	0.483	364	0.981	321	2.099

\* P&lt;0.05

\*\* P&lt;0.01

**Annex Table 2 : Least Square Analysis of Variance of the physical measurement parameters of Black Bengal goats – effectwise.**

Effect	Physical measurement traits									
	Body length		Wither height		Heart Girth		Paunch Girth		CC	
Source	df	MS	df	MS	df	MS	df	MS	df	MS
Zone	1	47.175**	1	176.145**	1	100.147**	1	488.809**	1	5.913**
Error	322	6.117	322	6.403	322	8.428	322	11.806	322	0.544
Sex	1	367.155**	1	573.631**	1	189.067**	1	108.034**	1	29.773**
Error	322	5.124	322	5.168	322	8.152	322	12.988	322	0.469
Lt Sz	2	100.426**	2	107.630**	2	199.907**	2	249.609**	2	10.981**
Error	321	5.658	321	6.301	321	7.521	321	11.810	321	0.495
Pty Kid	8	11.085	8	6.275	8	13.903	8	41.206**	8	1.093*
Error	315	6.122	315	6.945	315	8.580	315	12.574	315	0.547
Sn Brt	2	4.555	2	5.870	2	25.697*	2	38.499*	2	0.328
Error	321	6.255	321	6.935	321	8.606	321	13.126	321	0.562

\* P&lt;0.05

\*\* P&lt;0.01

**Annex Table 3 : Least Square Analysis of Variance of the haematological parameters of Black Bengal goats – effectwise.**

Effect	Haematological parameters											
	TEC		TLC		Neutrophils		Lymphocytes		Monocytes		Eosinophils	
Source	df	MS	df	MS	df	MS	df	MS	df	MS	df	MS
Zone	1	22.581**	1	0.642*	1	12.630	1	5.805	1	2.493	1	6.189*
Error	182	0.458	182	0.165	182	8.011	182	5.038	182	0.932	182	1.456
Sex	1	5.592**	1	0.253	1	2.992	1	12.564	1	1.034	1	0.042
Error	182	0.551	182	0.167	182	8.064	182	5.001	182	0.940	182	1.490
Season	2	0.718	2	1.063**	2	3.722	2	1.468	2	1.630	2	4.910*
Error	181	0.577	181	0.157	181	8.084	181	5.082	181	0.932	181	1.444

\* P&lt;0.05

\*\* P&lt;0.01

**Table 3 (contd...) :**

Effect	Haematological parameters											
	Basophils		Hb		PCV		MCV		MCH		MCHC	
Source	df	MS	df	MS	df	MS	df	MS	df	MS	df	MS
Zone	1	0.218	1	27.202**	1	256.142**	1	12.412	1	1.137*	1	0.884
Error	182	0.368	182	0.841	182	17.117	182	4.951	182	0.218	182	6.674
Sex	1	0.650	1	2.692	1	103.353**	1	2.385	1	0.016	1	7.814
Error	182	0.364	182	0.976	182	18.231	182	5.006	182	0.224	182	6.636
Season	2	0.036	2	0.298	2	3.783	2	3.589	2	0.364	2	0.223
Error	181	0.369	181	0.993	181	18.585	181	5.007	181	0.221	181	6.713

\* P&lt;0.05

\*\* P&lt;0.01

**Annex Table 4 : Least Square Analysis of Variance of serum trace minerals of Black Bengal goats – effectwise.**

Effect	Serum trace minerals									
	Iron		Copper		Zinc		Manganese		Cobalt	
Source	df	MS	df	MS	df	MS	df	MS	df	MS
Zone	1	97.522**	1	3.352*	1	1.358*	1	0.122	1	0.217
Error	182	14.863	182	0.948	182	0.360	182	0.694	182	0.136
Sex	1	1.773	1	0.272	1	0.016	1	0.070	1	0.417*
Error	182	15.390	182	0.966	182	0.365	182	0.694	182	0.132
Season	2	6.473	2	0.653	2	1.228*	2	0.321	2	0.115
Error	181	15.413	181	0.966	181	0.351	181	0.695	181	0.137

\* P&lt;0.05

\*\* P&lt;0.01

**Annex Table 5 : Fitted equations of body weight of Black Bengal goats with respect to days after birth of Terai and Hill zones of West Bengal.**

Models	R <sup>2</sup>	Level of Significance	b <sub>0</sub>	b <sub>1</sub>	b <sub>2</sub>
LIN	0.906	0.000	1.724	0.048	
QUA	0.921	0.000	1.323	0.069	-0.0001
COM	0.776	0.000	1.764	1.011	
GRO	0.776	0.000	0.567	0.011	
EXP	0.776	0.000	1.764	0.011	