

# **GENETIC EVALUATION OF BANDUR SHEEP UNDER FIELD CONDITIONS**

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By

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**CERTIFICATE**

This is to certify that the thesis entitled “**Genetic Evaluation of Bandur Sheep Under Field Conditions**” submitted by **M. Vasundara Devi**, DVHK-1003 (PVK 403) in partial fulfillment of the requirements for the award of **DOCTOR OF PHILOSOPHY in ANIMAL GENETICS AND BREEDING** of the Karnataka Veterinary, Animal and Fisheries Sciences University, Bidar is a record of bona-fide research work carried out by her during the period of her study in the University under my guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship of other similar titles.

BANGALORE  
10<sup>th</sup> MAY, 2013

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**AFFECTIONATELY DEDICATED TO MY BELOVED  
DAUGHTER "PRIYA"**

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## CONTENTS

<b>Sl. No.</b>	<b>Particulars</b>	<b>Page No.</b>
<b>I</b>	<b>INTRODUCTION</b>	<b>1-4</b>
<b>II</b>	<b>REVIEW OF LITERATURE</b>	<b>5-63</b>
<b>III</b>	<b>MATERIALS AND METHODS</b>	<b>64-89</b>
<b>IV</b>	<b>RESULTS</b>	<b>90-118</b>
<b>V</b>	<b>DISCUSSION</b>	<b>119-151</b>
<b>VI</b>	<b>SUMMARY</b>	<b>152-156</b>
<b>VII</b>	<b>BIBLIOGRAPHY</b>	<b>159-176</b>
<b>VIII</b>	<b>ABSTRACT</b>	<b>177</b>

## LIST OF TABLES

Table No.	Description	Page No.
1	Overall and sex-wise mean three months body weight (kg) in various breeds of sheep	12-13
2	Overall and sex-wise mean values of six months body weight (kg) in various breeds of sheep	15-16
3	Mean nine months body weight (kg) of lambs in various breeds of sheep	17
4	Overall and sex-wise mean twelve months body weight (kg) in various sheep breeds	19-20
5	Overall and sex-wise mean adult body weights (kg) in sheep	21-22
6	Overall and sex-wise mean body measurements (cm) of three months lambs in various breeds of sheep	24-25
7	Overall and sex-wise mean body measurements (cm) of six months in various breeds of sheep	27
8	Mean body measurements (in cm) of nine months lambs in various breeds of sheep	29
9	Overall and sex-wise mean body measurements (cm) of twelve months sheep in various breed	31-32
10	Overall and sex-wise mean body measurements (cm) of adult sheep in various of breeds	34-36
11	Means and standard errors of age at first lambing (days) in various breeds of sheep	45
12	Means and standard errors of lambing interval (days) in various breeds of sheep	46
13	Estimates of heritability with standard error of three months body weight in various breeds of sheep	49
14	Estimates of heritability with standard error for six months weight in various breeds of sheep	50
15	Estimates of heritability with standard error for nine months weight in various breeds of sheep	51
16	Estimates of heritability with standard error for twelve months weight in various breeds of sheep	52
17	Taluk wise number of villages covered in each district for detailed stratified random survey of Mandya sheep	66
18	Classification of data ( number of observations)	79
19	Morphological features of adult Bandur sheep	92
20	Sex and district wise least square means for body weights (kg) at various age groups	96
21	Mean square from least square analysis of variance for body weights at various age groups	97
22	Sex and district wise least square means for chest girth (cm) of different age groups	99
23	Mean square from least square analysis of variance of chest girth for various age groups	100

<b>Table No.</b>	<b>Description</b>	<b>Page No.</b>
24	Sex and district wise least square means for body length (cm) of different age groups	101
25	Mean square from least square analysis of variance for body length (cm) of different age groups	102
26	Sex and district wise least square means for height at withers at various age groups	103
27	Mean square from least square analysis of variance of height at withers for different age groups	104
28	District wise means along with standard error for age at first lambing and lambing interval (days )	113
29	Mean squares from analysis of variance for age at first lambing and lambing intervals	113
30	Mean squares from analysis of variance for heritability estimates of body weights at different ages	115
31	Heritability ( $h^2$ ) estimates for body weights at different ages	115
32	Correlation estimates between body weights and body measurements at six and twelve months	117
33	Multiple and linear regression equations for predicting six and twelve month body weight in Bandur sheep	119

## LIST OF FIGURES

<b>Figure No.</b>	<b>Description</b>	<b>Page No.</b>
<b>1</b>	<b>Survey area of Bandur sheep in home tract</b>	<b>65</b>
<b>2</b>	<b>Fifteen days old Bandur lambs</b>	<b>72</b>
<b>3</b>	<b>Three months old Bandur lamb</b>	<b>72</b>
<b>4</b>	<b>Bandur Ram (2 teeth )</b>	<b>73</b>
<b>5</b>	<b>Bandur Ram (4 teeth )</b>	<b>73</b>
<b>6</b>	<b>Bandur ewe (4 teeth )</b>	<b>76</b>
<b>7</b>	<b>Ewe with suckling lamb</b>	<b>76</b>
<b>8</b>	<b>Typical fore head and nose of Bandur sheep</b>	<b>77</b>
<b>9</b>	<b>Typical fore head and nose of Bandur sheep without wattles</b>	<b>77</b>
<b>10</b>	<b>Bandur ram with progenies (lambs)</b>	<b>86</b>
<b>11</b>	<b>Flock of Bandur sheep</b>	<b>86</b>



# **INTRODUCTION**

## I. INTRODUCTION

Sheep husbandry is an important enterprise from temperate to tropical ecology of India. Sheep are reared mainly by the poorest people on the lowest strata of the society and serve as the main or supplementary source of income among this category. Sheep are reared for its multiple usefulness (meat, wool, skin and manure) and they are mobile banks for the farmers. Sheep have close grazing nature and ability to utilize very low set vegetation and excellent ability to survive over a prolonged period of drought and semi-starvation.

India has 42 well defined and characterized breeds of sheep and many uncharacterized / unrecognized desi / non -descript breeds. The total sheep population in India in 2007 was 71.55 million and ranked third in the world. The estimated meat production from sheep was 2,91,000 tonnes in 2008-09 and the estimated value of meat produced by sheep and goat was Rs. 17,043 crores (2008-09) whereas, estimated wool production was 42.9 million kg worth of 259 crores in 2008-09 (Anon, 2010). In India, per capita availability of meat is 5gm per day (Singh *et al.*, 2005) while recommended is 30gm per day (ICMR).

The number of countries to which Indian meat is exported has increased from about 30 in 1994-95 to 50 in 1999-2000 (Singh *et al.*, 2005). Sheep and goat meat export increased by 71 per cent during the year from 2008-09 to 2009-10. Lamb and sheep meat formed about 9.57 per cent in quantity and about 11.80 per cent in value terms of the total meat exports in 2009-10 (Anon., 2010).

In comparison to India, sheep population in Karnataka is 95.32 lakhs (Anon., 2007) and ranks third in the country. Sizeable sheep populations of the state are non-

descript which have undergone indiscriminate breeding and inter-mixing of breeds. Estimated production of meat from sheep is 39,063 tonnes and 60 per cent of the state's population consumes meat. The average meat yield per sheep was 16.54 kg. (Anon., 2011-12) and estimated wool production was 7779 tonnes (2011-12) registering 8.38 per cent growth over 2010-11 production (Anon., 2011-12).

The indigenous sheep breeds are essentially the product of long term natural selection under low input and harsh climatic conditions. As most of the sheep breeds are sustaining themselves under the low input system, there is a dwindling trend in the population of some of the breeds. The reason may be due to indiscriminate cross breeding, low remuneration from sheep. Other causes include slaughtering of growing lambs at the rate of 30-40 per cent at 6-9 month of age for lean meat production and degradation of habitat and grazing area due to increased irrigation leading to more area under crop cultivation and deforestation (Jain, 2004).

Mandya / Bandur breed of sheep has been in lime light as an outstanding and the best mutton breed of the Karnataka state and country over centuries for production of excellent quality of mutton (Acharya, 1982). This breed is pre-dominantly distributed in Mandya district and distributed in fairly large numbers in the adjacent districts of Bangalore Rural, Chamarajanagar, Hassan, Mysore and some taluks of Tumkur and Kolar. This breed was used as one of the parental indigenous breed to develop synthetic meat line called "Avikalin" under AICRP on mutton, at CSWRI, ICAR, Avikanagar, Rajasthan. This breed was also used as one of the parental line to evolve a dual purpose breed in the erstwhile University of Agricultural Sciences, Bangalore at Dharwad Campus in early seventies and released as "Improved UAS strain of sheep", for the benefit of sheep farmers in the state.

Sheep belonging to Mandya / Bandur breed are stocky in body built and relatively small in body size, with compact and square type shape with well sprung ribs attached with thick muscles, face is clean and devoid of long hairs or wool and nose is elongated and slightly convex indicative of the shape of Roman nose. Polled condition is a normal feature in both sexes of this breed. The body weight of Bandur sheep is low when compared to exotic sheep breeds and some of the sheep breeds in the north-west region of the country. This breed is in great demand either for upgrading of the local sheep or for crossing with exotic sheep breeds with which it has excellent combining ability. It is regularly being slaughtered at high rate for production of quality tender meat, during certain festivals of the region. Probably this would be one of the causes for depletion in its number overtime in the breeding tract.

Mandya / Bandur breed of sheep is a reservoir of vast genetic diversity. However, it still remains under improved in terms of production levels and genetic improvement within the prevailing systems of farming and managerial practices.

Indigenous breeds with specific qualities like heat tolerance, disease resistance ability to survive and produce under stress and low input conditions need to be preserved for future use. Also breeds with unique traits will be essential for long-term research plans as they are important gene pool to work with.

There is a need to generate information on morphology, body measurements and economic parameters related to production and reproduction and survival in their native tract. In addition, available feed resources and prevalent management practices and systems need to be documented.

Keeping in view of the rich genetic architecture of the breed and its importance to enhance in numbers and production in home / native tract and

availability of limited information on Mandya / Bandur breed with regard to its morphological, production, reproduction and body measurements etc., for genetic evaluation of Bandur breed, the research study were contemplated with the following objectives.

1. To compile information on phenotypic or morphological traits of Bandur breed of sheep.
2. To assess performance of growth and reproductive traits.
3. To predict body weight at 6 and 12 months of age based on body measurements.
4. To estimate genetic parameters of traits of economic importance.



# **REVIEW OF LITERATURE**

## II. REVIEW OF LITERATURE

The literature pertaining to morphological traits of various breeds, body weights and body measurements at 3 months ( $\leq 3$ ), 6 months ( $\leq 6$ ), 9 months ( $\leq 9$ ), 12 months ( $\leq 12$ ) and adults ( $\geq 12$ ), corresponding to reproductive traits, age at first lambing (AFL) and lambing interval (LI), heritability estimates within yearling age, phenotypic correlation of body weights with body measurements at six and twelve months of age and prediction of body weights from body measurements in various sheep breeds, have been reviewed individually.

While reviewing literature for different age groups, i.e., the literature pertaining to 3, 6, 9, 12 months and adult, and mean values for various traits, preference has been given to studies conducted in Indian breeds and synthetics evolved over years. For estimates of genetic parameter, those reported in Indian breeds, crossbreeds and exotic breeds have been reviewed.

### 2.1 Breed characteristics / morphological traits of sheep

Bonpala sheep is a dual purpose breed found in Sikkim and eastern Nepal. Vij *et al.* (1997) conducted a sample survey to record breed morphological traits, which indicated that Bonpala sheep have mixed colour ranging from all white, white and black or all black. They are small in size. Face, neck, knees, legs and hooves are generally black or colour, muzzle is white or pink in colour. Nose is typically Roman type. Horns are thick and long in rams, thin and small in ewes. Ears are short and tubular. Tail is short, belly and legs are devoid of wool. These observations were in similarity to the earlier report of Acharya (1982).

Chokla sheep are a finer carpet wool producing Indian breed of sheep. As per the survey conducted by Kushwaha *et al.* (1997) to characterize the Chokla sheep in its home tract, the animals are light to medium size with square compact body and a small head, reddish brown or dark tan in colour, with a white body and pink skin. Both sexes are polled, wattles are absent, tail is thin and the coat is dense and relatively fine, covering the entire body including the belly and greater part of the legs. The ewes generally show poor maternal behavior.

As per the studies conducted by Raman *et al.* (2003) and the report of Anon. (2013) Madras red breed of sheep are medium sized, well built, hairy type with tucked up bellies, long legs with clean bony limbs, with flat short tail. Body colour varied from light to dark red / brown / tan and the forehead is straight (97.2%). These sheep had a characteristic couple of pendulous lobules as tassles. Rams had corrugated horns while ewes are polled. The hooves predominantly black. White markings were seen in both sexes on forehead, ventral region, on thighs and lower limbs and also on body.

As per the monograph by Anon. (2004a) on Mecheri sheep the body colour variants noted were light brown (42.20%), light brown with white patch on head (20.64%), light brown with white colour legs and sides of body (25.67%), light brown with white spots (10.09%) and completely white colour (1.40). Mecheri sheep were classified under polled breeds, as per the survey report 16.3 per cent of males were horned. The wattles were observed in both sexes. In 49 per cent males and 46 per cent female sheep wattles were noted. Beard was present only in 6-5 per cent of the males and absent in females.

Anon. (2004b) report described the Deccani breed of sheep as long legged bony animal, poor in chest with a long thin neck and lacks depth of body. Breed is having flat forehead and a distinct Roman nose with short pointed muzzle. The shape of the ears vary much in these sheep. Ewes are generally polled whereas rams are always with horns. The colour of sheep is black in general. Wool is both short and long, and harsh to touch. The sheep of different age groups did not have wattles and also had slender curved tail of medium length.

Hassan breed of sheep as been described by Jain *et al.* (2006) as small to medium sized breed with coat colour ranging from white or white with light brown or black spots on head and different parts of the body. Ears are medium long and alert. Females are usually polled and about 30-40 per cent of the males are horned and remaining polled. Tail is thin and of average length.

As per the reports of Karunanithi *et al.* (2005) Mecheri sheep is a medium sized sheep with compact body and covered with short hairs. They are light brown in colour with little white patches. The skin of Mecheri sheep is pinkish white in colour and both sexes are polled. The head is medium in length with broad medium to broad forehead, with slightly Roman nose. The ears are medium long, leaf like and semi pendulous and have brown coloured muzzles. Wattles are present in both sexes. The hooves are brown or black in colour. The tail is short and “V” shaped.

As per the reports of Arora *et al.* (2005), Garole is a small sized breed with a relatively low body weight in comparison to other breeds of sheep. It has a compact and square body with a small head, medium ears and a short thin tail. Grey and white are predominant colours in this breed males were horned and females were polled. The fleece is open and very coarse and covers entire body.

Dixit *et al.* (2005) reported the breed characteristics of Rampur Bushair, a dual purpose sheep in north temperate Himalayas region of Himachal Pradesh. The sheep were strong, well built medium sized with mostly white colour, but black, brown and mottled were also found. A typically prominent Roman nose, convex head, large eyes and pendulous ears and prominent mid-ridge are peculiar characteristics of this breed. The rams had medium to long curled horns and ewes were polled.

Jain *et al.* (2005) reported the breed profile of Bellary breed which is a native breed of Bellary and surrounding districts of Karnataka. Animals are strong built and medium to large in size. The coat colour of the 186 sheep surveyed was completely black (36.6 per cent), black with white spots (22.0 per cent), black with white spots (14.0 per cent). Of the surveyed sheep, 89 per cent of the rams and 95 per cent of the ewes were observed as horned. Ears were alert, tubular in shape and medium in size, tail was short and thin. The body was covered with coarse hairy and open fleece. Face, belly and legs were devoid of wool and they were similar to the reports of Acharya (1982) except for body weights

Tailor *et al.* (2006) reported the breed profile of Sonadi breed of sheep of Udaipur of Rajasthan. These sheep are said to have well built large body with long legs. The face of the animal is white or light brown and colour extends upto the middle of the neck. The nose is prominent, large dropping ears and long and thin tail. The face, abdomen and legs are free from the wool. The colour of the fleece is white but coarse and hairy.

Muzzafarnagari sheep are one of the heaviest and tallest sheep breeds of India as reported by Dass and Hariprasad (2007). The sheep have forehead slightly convex, face and body is white with occasional brown or black patches. The breed has broad

forehead with prominent and shining eyes. Fleece is white and coarse type. Belly, face, ears and legs are devoid of wool. Ears were long, broad, flat and drooping. Both sexes are polled, legs are long and straight and tail is very long extending upto fetlock joints with hairy wool cover.

Jain and Singh (2008) conducted survey to characterize Balangir breed of sheep of Orissa. As per the reports presented by them, the sheep of this breed are medium sized. The body weight was  $23.0 \pm 0.74$  kg and  $20.4 \pm 0.17$  kg in rams and ewes, respectively. Coat colour ranged from light to dark brown or patches of white and brown colour, ears were stumpy or small and tubular. Males were horned and females polled, tail was small and thin. Body was covered with coarse, open and coloured fleece. Face, belly and legs were devoid of wool.

Arora *et al.* (2008) studied the breed characteristics of Ganjam sheep breed of Orissa, which is reared mainly for meat. This sheep are medium sized with hairy fleece. Their coat colour varied from brown to dark tan and average flock size was 35.

Devendran *et al.* (2008) reported that Coimbatore sheep breed is a coarse carpet wool breed of Tamil Nadu reared mainly for meat production. The sheep are medium sized sheep and they are white in colour with varying extent of black or tan fleece on the head and neck, extends upto shoulder or back. The head is small and convex slightly. Males are polled (65%) or horned and females are polled. The fleece is open and coarse.

Gurez breed is from native tract of Jammu and Kashmir as reported by Anon. (2013). The animals are known for excellent mutton production and long carpet wool. The forehead is slightly convex with medium ears and medium to coarse wool

covering entire body. In Gurez sheep the coat colour variants were white (49.26%), brown (36.65%) and black (14.07%). Horns were present in 84.60 per cent males whereas females were generally polled (82.98%).

In Karnah breed, the coat colour noted was 100 per cent white in rams, while in ewes the colours seen were 91.72 per cent white 4.03 per cent brown and 4.23 per cent black. Horns were present in rams (94%) whereas females were polled (100%). Wattles and beard were absent (Anon., 2013).

In Niligiri breed of Tamil Nadu coat colour observed was white, whereas about 32.6 per cent of the surveyed population showed brown to tan patches, black spots, dots or hairs. Variants for shape of the forehead reported were convex (68.4%), some slightly convex (23.2%) and straight (8.4%). The shape of the ear noted was pendulous (72%), horizontal (18.8%) or short (9.2%). Wattles were present in 5 per cent of sheep. Horns were absent. (Anon., 2013).

As per breed descriptor of sheep report by Jain *et al.* (2008) Mandya sheep of Karnataka, the coat colour is white with light brown face usually extending up to neck. Head profile is straight to slightly convex, ears medium long in size and drooping, with wattles present and horns absent in both sexes and scurs seen in males rarely. Head, face, belly, legs are devoid of wool. Wool type is coarse and specifically meat production type.

As per the breed descriptors of sheep by Anon. (2008), Chotanagpuri is a native breed of Jharkhand state in and around Ranchi, Saraikela etc. The animals are small sized with straight head and with coarse wool. In Chotanagpuri breed the distinctive coat colour were of four variants, brown (48.89%), white (33.80%), black (12.35%) and black and brown (4.97%), and wattles were absent in both the sexes

(100%). Ears were horizontal in 75.17 per cent, pendulous in 16.49 per cent and stumpy in 8.34 per cent. Head profile was reported as straight. Horns were present only in males and absent in females. Shape of the horn was curved in 98.27 per cent sheep and straight in 1.73 per cent, and colour of horn was grey (94.15%) or black (5.85%).

Nali breed of sheep are from Rajasthan known for carpet wool production (Anon., 2008). The other breed characteristics presented were straight head profile with pendulous ears, white coloured coat and brown coloured face, and horns absent in both sexes. Body is covered with coarse wool except legs. Tail is thin and straight.

## **2.2 MEAN VALUES**

### **2.2.1 BODY WEIGHTS**

Body weights are the important economic traits in sheep production and forms the basis for breeders to select and improve other traits.

#### **2.2.1.1 THREE MONTHS WEIGHT**

Three months weight in sheep is important because of its association with post-weaning growth and adult body weight (Dass and Acharya, 1970), and is also related with mothering ability.

The mean values of three month weight reported by various investigators for different breeds are presented in Table 1. The overall three months body weight ranged from  $5.10 \pm 0.16$  kg in Rampur Bushair breed (Dixit *et al.*, 2005) to  $17.70 \pm 0.05$  kg in Pugal sheep (Dass, 2007).

In ram lambs, mean values of three months weight varied from  $4.61 \pm 0.26$  kg in Mandya sheep ( Jayashnkar *et.al.*,2008) to  $18.90 \pm 0.18$  kg in Madgyal sheep

**Table 1 : Overall and sex-wise mean three months body weight (kg) in various breeds of sheep**

<b>Breed</b>	<b>Overall (<math>\bar{X} \pm SE</math>) (kg)</b>	<b>Male (<math>\bar{X} \pm SE</math>) (kg)</b>	<b>Female (<math>\bar{X} \pm SE</math>) (kg)</b>	<b>References</b>
Avikalin	15.36 $\pm$ 0.18 (1313)	16.36 $\pm$ 0.21 (481)	14.76 $\pm$ 0.18 (832)	Maroof Ahmad <i>et al.</i> (2004)
Avikalin crossbred	15.43 $\pm$ 2.70	-	-	Maroof Ahmad <i>et al.</i> (2005)
Bannur	8.82 $\pm$ 0.07	-	-	Urala (1977)
Bannur	8.89 $\pm$ 0.05	9.33 $\pm$ 0.07	8.44 $\pm$ 0.08	Dikshit (1981)
Bannur	8.15 $\pm$ 0.03	-	-	Rajkumar (1981)
Bannur	10.98 $\pm$ 2.56	-	-	Nagaraja <i>et al.</i> (1996)
Chokla	12.9 $\pm$ 0.12 (980)	13.3 $\pm$ 0.14 (478)	12.6 $\pm$ 0.14 (502)	Kushwaha <i>et al.</i> (1997)
Coimbatore	12.4 $\pm$ 0.39 (145)	12.92 $\pm$ 0.49 (36)	11.91 $\pm$ 0.37 (109)	Anon (2006)
Ganjam	11.03 $\pm$ 0.07 (143)	11.12 $\pm$ 0.10	10.93 $\pm$ 0.10	Mishra <i>et al.</i> (2004)
Indigenous meat type sheep (Orissa)	8.60 $\pm$ 0.05 (510)	9.31 $\pm$ 0.09 (199)	8.15 $\pm$ 0.65 (311)	Pattanayak <i>et al.</i> (2003)
Indigenous strain (Orissa)	6.68 $\pm$ 0.03	6.86 $\pm$ 0.04	6.50 $\pm$ 0.04	Patro <i>et al.</i> (2006)
Jaisalmeri	14.99 $\pm$ 0.11 (684)	14.47 $\pm$ 0.19 (193)	15.32 $\pm$ 0.12 (491)	Arora <i>et al.</i> (2005)
Kheri	10.8 $\pm$ 0.16 (248)	-	-	Sushil Kunal <i>et al.</i> (2003)
Madgyal	-	18.90 $\pm$ 0.18 (93)	17.58 $\pm$ 0.17 (120)	Waghmode <i>et al.</i> (2008)
Madras Red	12.79 $\pm$ 0.11	12.79 $\pm$ 0.17	12.78 $\pm$ 0.16	Raman <i>et al.</i> (2003)
Malpura	11.57 $\pm$ 0.11 (791)	11.86 $\pm$ 0.16 (342)	11.27 $\pm$ 0.15 (449)	Sharma <i>et al.</i> (2003b)
Malpura	9.86 $\pm$ 0.13 (397)	-	-	Sushil Kumar <i>et al.</i> (2003)
Mandya (0-3 months)	-	4.61 $\pm$ 0.26	5.65 $\pm$ 0.30	Jayashankar <i>et al.</i> (2008)
Marwari	11.47 $\pm$ 0.04 (1212)	-	-	Sharma <i>et al.</i> (2003a)

**Table 1 : Contd...**

<b>Breed</b>	<b>Overall (<math>\bar{X} \pm SE</math>) (kg)</b>	<b>Male (<math>\bar{X} \pm SE</math>) (kg)</b>	<b>Female (<math>\bar{X} \pm SE</math>) (kg)</b>	<b>References</b>
Marwari	11.78 $\pm$ 0.20 (631)	12.21 $\pm$ 0.22 (268)	11.36 $\pm$ 0.20 (363)	Nehra and Singh (2006)
Mecheri	10.9 $\pm$ 0.1	11.0 $\pm$ 0.1 (259)	10.8 $\pm$ 0.1 (348)	Karunanithi <i>et al.</i> (2005)
Mecheri	7.40 $\pm$ 1.17	-	-	Thiruvenkadan <i>et al.</i> (2008)
Munjal	16.87 $\pm$ 1.03 (172)	17.61 $\pm$ 1.06 (92)	16.13 $\pm$ 1.06 (80)	Poonia (2004)
Muzzaffarnagari	-	14.85 $\pm$ 0.43 (40)	14.05 $\pm$ 0.09 (36)	Dinesh Kumar <i>et al.</i> (2006)
Nali	12.53 $\pm$ 0.03 (562)	-	-	Sharma <i>et al.</i> (2003a)
Nali	10.66 $\pm$ (547)	10.65 (258)	10.09 (289)	Bapaditya and Poonia (2005)
Pugal	17.70 $\pm$ 0.05 (1096)	18.0 $\pm$ 0.09 (474)	17.28 $\pm$ 0.06 (662)	Dass (2007)
Rampur Bushiar	5.10 $\pm$ 0.16 (49)	-	-	Dixit <i>et al.</i> (2005)
Sonadi	10.65 $\pm$ 0.05	-	-	Tailor <i>et al.</i> (2006)

\* Number of observation are given in parenthesis

(Waghmode *et al.*, 2008) and in ewe lambs from  $6.50 \pm 0.04$  kg in indigenous sheep of Orissa (Patro *et al.*, 2006) to  $17.58 \pm 0.17$  kg in Madgyal sheep (Waghmode *et al.*, 2008).

#### **2.2.1.2 SIX MONTHS WEIGHT**

Post weaning body weights are free from maternal influences and reflect the genetic potential of the lamb. Among post weaning weights six months weight is the first measurable trait and is also considered as a selection criterion to improve the market weight. The average six months weight reviews are presented in Table 2.

Singh and Singh (1984) reported mean six months body weight of pooled as  $9.87 \pm 0.03$ kg, for rams and ewes as  $10.42 \pm 0.52$ kg and  $9.56 \pm 0.42$  kg, respectively in Coimbatore sheep. Poonia (2004) observed average six months body weight of overall as  $27.64 \pm 0.57$ kg, for rams and ewes as  $28.09 \pm 0.63$ kg and  $26.20 \pm 0.63$  kg in Munjal sheep respectively.

#### **2.2.1.3 NINE MONTHS WEIGHT**

Nine months body weight is important because it is considered as marketing age in most of the meat breeds. The mean values of nine months weight reported for different breeds of sheep are presented in Table 3. The lowest and highest nine months weight of 12.09 kg and 27.55 kg were recorded in Coimbatore (Singh and Singh, 1984) and Madgyal (Waghmode *et al.*, 2008) breeds of sheep, respectively.

#### **2.2.1.4 TWELVE MONTHS WEIGHT**

The overall mean values reviewed for twelve months weight of various breeds of sheep is detailed in Table 4.

**Table 2 : Overall and sex-wise mean values of six months body weight (kg) in various breed of sheep**

<b>Breed</b>	<b>Overall (<math>\bar{X} \pm SE</math>) (kg)</b>	<b>Male (<math>\bar{X} \pm SE</math>) (kg)</b>	<b>Female (<math>\bar{X} \pm SE</math>) (kg)</b>	<b>References</b>
Avikalin	20.97 $\pm$ 0.26 (1313)	22.47 $\pm$ 0.28	19.48 $\pm$ 0.26	Maroof Ahmad <i>et al.</i> (2004)
Avikalin crossbred	21.17 $\pm$ 3.62	-	-	Maroof Ahmad <i>et al.</i> (2005)
Bannur	11.30 $\pm$ 0.08	-	-	Urala (1977)
Bannur	12.30 $\pm$ 0.06	-	-	Dikshit (1981)
Bannur	17.72 $\pm$ 2.94	-	-	Nagaraja <i>et al.</i> (1996)
Chokla	17.4 $\pm$ 0.17 (807)	18.5 $\pm$ 0.20 (381)	16.23 $\pm$ 0.20 (426)	Kushwaha <i>et al.</i> (1997)
Coimbatore	9.87 $\pm$ 0.3 (44)	10.42 $\pm$ 0.52 (16)	9.56 $\pm$ 0.42 (28)	Singh and Singh (1984)
Coimbatore	10.83 $\pm$ 0.23 (207)	-	-	Acharya (1982)
Coimbatore	15.93 $\pm$ 0.25 (150)	17.23 $\pm$ 0.35 (38)	14.64 $\pm$ 0.25 (112)	Kandasamy <i>et al.</i> (2006)
Ganjam	15.65 $\pm$ 0.11 (132)	16.31 $\pm$ 0.15	14.97 $\pm$ 0.17	Mishra <i>et al.</i> (2004)
Indigenous meat type sheep (Orissa)	12.92 $\pm$ 0.08 (251)	13.82 $\pm$ 0.18 (83)	12.48 $\pm$ 0.08 (168)	Pattanayak <i>et al.</i> (2003)
Indigenous strain (Orissa)	11.02 $\pm$ 0.05	10.56 $\pm$ 0.04	10.79 $\pm$ 0.03	Patro <i>et al.</i> (2006)
Jaisalmeri	22.91 $\pm$ 0.18 (630)	23.37 $\pm$ 0.32 (117)	22.26 $\pm$ 0.15 (513)	Arora <i>et al.</i> (2005)
Kheri	15.97 $\pm$ 0.10	16.61 $\pm$ 0.13 (239)	14.94 $\pm$ 0.08 (600)	Sushil Kunal <i>et al.</i> (2003)
Madgyal	25.72 $\pm$ 0.25 (93)	-	-	Waghmode <i>et al.</i> (2008)
Madras Red	18.20 $\pm$ 0.16	18.16 $\pm$ 0.36	18.16 $\pm$ 0.18	Raman <i>et al.</i> (2003)
Malpura	18.5 $\pm$ 0.14 (794)	19.7 $\pm$ 0.20 (372)	17.26 $\pm$ 0.19 (422)	Sharma <i>et al.</i> (2003b)
Malpura	15.58 $\pm$ 0.11	-	-	Sushil Kumar <i>et al.</i> (2003)
Mandya (3-6 months)	-	10.47 $\pm$ 0.55	12.37 $\pm$ 0.07	Jayashankar <i>et al.</i> (2008)

**Table 2 Contd...**

<b>Breed</b>	<b>Overall (<math>\bar{X} \pm SE</math>) (kg)</b>	<b>Male (<math>\bar{X} \pm SE</math>) (kg)</b>	<b>Female (<math>\bar{X} \pm SE</math>) (kg)</b>	<b>References</b>
Marwari	15.51 $\pm$ 0.56 (1148)	-	-	Sharma <i>et al.</i> (2003a)
Marwari	16.45 $\pm$ 0.28	17.21 $\pm$ 0.30	15.68 $\pm$ 0.28	Nehra and Singh (2006)
Mecheri	15.6 $\pm$ 0.1	17.6 $\pm$ 0.3 (119)	15.2 $\pm$ 0.2 (586)	Karunanithi <i>et al.</i> (2005)
Mecheri	11.47 $\pm$ 0.71	-	-	Thiruvankadan <i>et al.</i> (2008)
Munjali	27.64 $\pm$ 0.57 (172)	28.09 $\pm$ 0.63 (92)	26.20 $\pm$ 0.62 (80)	Poonia (2004)
Muzzaffarnagari	-	20.78 $\pm$ 0.74 (27)	20.18 $\pm$ 0.71 (33)	Dinesh Kumar <i>et al.</i> (2006)
Nali	16.36 $\pm$ 0.03 (497)	-	-	Sharma <i>et al.</i> (2003a)
Nali	14.14 (404)	15.02 (150)	13.82 (254)	Bapaditya and Poonia (2005)
Pugal	23.67 $\pm$ 0.09 (671)	24.24 $\pm$ 0.14 (234)	23.09 $\pm$ 0.10 (437)	Dass (2007)
Rampurbushiar	10.03 $\pm$ 0.33 (58)	-	-	Dixit <i>et al.</i> (2005)
Sonadi	16.07 $\pm$ 0.08	-	-	Tailor <i>et al.</i> (2006)

\* Number of observation are given in parenthesis

**Table 3 : Mean nine months body weight (kg) of lambs reported in various breeds of sheep**

Breed	Numbers	Overall ( $\bar{X} \pm SE$ ) (kg)	References
Balangir		14.24 $\pm$ 0.10	Mohanty and Mishra (1992)
Bannur		21.74 $\pm$ 3.38	Nagaraja <i>et al.</i> (1996)
Chokla	8	14.57 $\pm$ 1.10	Arora <i>et al.</i> (1983)
Coimbatore	37	12.09 $\pm$ 0.79	Singh and Singh (1984)
Coimbatore	143	18.58 $\pm$ 0.23	Kandasamy <i>et al.</i> (2006)
Deccani	314	19.65 $\pm$ 0.70	Kulkarni and Deshpande (1986b)
Ganjam		15.43 $\pm$ 0.14	Mohanty and Mishra (1992)
Ganjam		16.51 $\pm$ 0.18	Pattanayak <i>et al.</i> (2003)
Kheri	482	19.88 $\pm$ 0.19	Kumar <i>et al.</i> (2003)
Madras Red	217	18.92 $\pm$ 0.34	Raman <i>et al.</i> (2003)
Madras Red	289	18.61 $\pm$ 0.02	Devendran <i>et al.</i> (2008)
Madgyal	213	27.55 $\pm$ 0.21	Waghmode <i>et al.</i> (2008)
Magra	409	16.98 $\pm$ 0.33	Sharma <i>et al.</i> (1991a)
Magra	225	20.38 $\pm$ 0.25	Mehta <i>et al.</i> (2003)
Malpura	137	21.19 $\pm$ 0.92	Singh <i>et al.</i> (1987)
Malpura	312	20.23 $\pm$ 0.18	Kumar <i>et al.</i> (2003)
Mandya	387	17.73	Narayanaswamy <i>et al.</i> (1975)
Mandya	134	13.48 $\pm$ 1.20	Arora and Acharya (1976)
Mandya	401	18.59 $\pm$ 0.22	Reddy and Rai (1987b)
Marwari	631	18.74 $\pm$ 0.33	Nehra and Singh (2006)
Mecheri	24	14.69	Ulaganathan <i>et al.</i> (1989)
Mecheri	1133	16.54 $\pm$ 0.26	Jagatheesan <i>et al.</i> (2003)
M	634	17.90 $\pm$ 0.25	
F	21	15.17 $\pm$ 0.27	
Mecheri	480	17.56 $\pm$ 0.15	Karunanithi <i>et al.</i> (2005)
M	89	19.38 $\pm$ 0.32	
F	391	17.14 $\pm$ 0.17	
Mecheri	6	14.67 $\pm$ 2.48	Thiruvankadan <i>et al.</i> (2008)
Muzzafarnagri	62	27.26 $\pm$ 0.86	Bhadula and Bhat (1980a)
Muzzafarnagri	739	24.25 $\pm$ 0.45	Kaila <i>et al.</i> (1989)
Muzzafarnagri	1545	24.69 $\pm$ 0.48	Mandal <i>et al.</i> (2003)
Nali	18	13.60 $\pm$ 0.39	Arora <i>et al.</i> (1983)
Nellore	290	21.00 $\pm$ 0.24	Reddy and Rai (1987b)
Nilagiri	1952	18.57 $\pm$ 0.15	Iyue (1993)
Nilagiri	695	17.85 $\pm$ 0.21	Panneerselvam (1993)
Sonadi	51	20.5 $\pm$ 0.92	Mehta <i>et al.</i> (1995)
Vembur	21	18.66 $\pm$ 0.26	Chandran (1998)

The highest overall twelve month body weight of  $31.00 \pm 0.23$  kg in Madgyal sheep was reported by Waghmode *et al.* (2008) and lowest body weight of  $16.04 \pm 0.11$  kg was reported by Urala (1977) in Bannur sheep.

The mean values of twelve month weight for rams ranged from  $17.70 \pm 0.03$  kg in Mecheri sheep (Thiruvankadan *et al.*, 2008) to  $31.50 \pm 2.81$  kg in Muzzafarnagari sheep (Dinesh Kumar *et al.*, 2006) while in ewes mean values varied from  $16.56 \pm 0.18$  kg in Mandya sheep (Jayashankar *et al.*, 2008) to  $32.35 \pm 0.80$  kg in Muzzafarnagari ewes (Dinesh Kumar *et al.*, 2006).

#### **2.2.1.5 ADULT BODY WEIGHT**

The mean values for adult body weight of various breeds are presented in Table 5. The highest overall adult body weight reported was  $42.61 \pm 0.82$  kg in Muzzafarnagari sheep (Dass and Hariprasad, 2007) and lowest body weight of 10.14 kg in Garole breed (Ghalasasi *et al.*, 1994).

The mean adult body weight of rams and ewes varied from  $21.14 \pm 0.45$  kg and  $20.46 \pm 0.45$  kg in Tumkur strain as reported by Dayananda (1998) to 65.93 kg and 45.37 kg in Munjal sheep, respectively as reported by Kushwaha *et al.* (1999b).

#### **2.2.2 BODY MEASUREMENTS**

Growth in sheep is measured in terms of increase in live weight. Body measurements like height at withers, body length chest girth and paunch or belly girth have also been used to predict body weight at specific ages. These body measurements are helpful in describing the breed characteristics on scientific lines (Mittal, 1988), evaluation of meat production potential (Taneja *et al.*, 1993) and

**Table 4 : Overall and sex-wise mean twelve months body weight (kg) in various sheep breeds**

<b>Breed</b>	<b>Overall (<math>\bar{X} \pm SE</math>) (kg)</b>	<b>Male (<math>\bar{X} \pm SE</math>) (kg)</b>	<b>Female (<math>\bar{X} \pm SE</math>) (kg)</b>	<b>References</b>
Avikalin	26.13 $\pm$ 0.31	28.15 $\pm$ 0.34	24.09 $\pm$ 0.32	Maroof Ahmad <i>et al.</i> (2004)
Avikalin crossbred	26.02 $\pm$ 4.31	-	-	Maroof Ahmad <i>et al.</i> (2005)
Bannur	16.04 $\pm$ 0.11	-	-	Urala (1977)
Bannur	16.39 $\pm$ 0.05	-	-	Rajkumar (1981)
Bannur	27.1 $\pm$ 3.51	-	-	Nagaraja <i>et al.</i> (1996)
Bannur	27.96 $\pm$ 0.47 (173)	-	-	Siddalinga Murthy (2001)
Bharath Merino	29.10 $\pm$ 0.30 (1560)	-	-	Dixit <i>et al.</i> (2001)
Chokla	22.0 $\pm$ 0.26 (557)	24.2 $\pm$ 0.30 (240)	19.8 $\pm$ 0.29 (337)	Kushwaha <i>et al.</i> (1997)
Coimbatore	21.52 $\pm$ 0.26 (124)	-	-	Kandasamy <i>et al.</i> (2006)
Coimbatore	23.65 $\pm$ 0.35 (169)	26.59 $\pm$ 0.53 (37)	20.82 $\pm$ 0.33 (132)	Anon (2006)
Ganjam	24.10 $\pm$ 0.12	24.6 $\pm$ 0.12	23.54 $\pm$ 0.16	Mishra <i>et al.</i> (2004)
Indigenous meat type sheep (Orissa)	22.95 $\pm$ 0.60	-	-	Pattanayak <i>et al.</i> (2003)
Indigenous strain (Orissa)	18.03 $\pm$ 0.01	18.21 $\pm$ 0.03	17.86 $\pm$ 0.02	Patro <i>et al.</i> (2006)
Jaisalmeri	27.81 $\pm$ 0.21 (427)	29.44 $\pm$ 0.39 (79)	26.18 $\pm$ 0.21 (348)	Arora <i>et al.</i> (2005)
Kheri	23.68 $\pm$ 0.27	27.02 $\pm$ 0.42	22.2 $\pm$ 0.11	Sushil Kunal <i>et al.</i> (2003)
Madgyal	31.00 $\pm$ 0.23 (213)	-	-	Waghmode <i>et al.</i> (2008)
Madras Red	18.61 $\pm$ 0.22 (70)	20.02 $\pm$ 0.41 (61)	0.28 (109)	Raman <i>et al.</i> (2003)
Madras Red	20.75 $\pm$ 0.02 (289)	-	-	Devandran <i>et al.</i> (2008)
Magra	24.84 $\pm$ 0.37 (282)	-	-	Mehta <i>et al.</i> (2003)

Table 4 : Contd....

<b>Breed</b>	<b>Overall (<math>\bar{X} \pm SE</math>) (kg)</b>	<b>Male (<math>\bar{X} \pm SE</math>) (kg)</b>	<b>Female (<math>\bar{X} \pm SE</math>) (kg)</b>	<b>References</b>
Malpura	25.61 $\pm$ 0.16 (511)	28.22 $\pm$ 0.25 (163)	23.00 $\pm$ 0.18 (348)	Sharma <i>et al.</i> (2003b)
Malpura	25.56 $\pm$ 0.26 (176)	-	-	Sushil Kumar <i>et al.</i> (2003)
Mandya	-	16.96 $\pm$ 0.32	10.50 $\pm$ 0.18	Jayashankar <i>et al.</i> (2008)
Marwari	20.64 $\pm$ 0.08 (1010)	-	-	Sharma <i>et al.</i> (2003a)
Marwari	20.70 $\pm$ 0.31	21.87 $\pm$ 0.35	19.53 $\pm$ 0.32	Nehra and Singh (2006)
Mecheri	21.1 $\pm$ 0.1	23.7 $\pm$ 0.3	20.4 $\pm$ 0.1	Karunanithi <i>et al.</i> (2005)
Mecheri	-	17.70 $\pm$ 1.03	17.68 $\pm$ 0.60	Thiruvankadan <i>et al.</i> (2008)
Muzzaffarnagari	-	31.50 $\pm$ 2.81	32.35 $\pm$ 0.80 (20)	Dinesh Kumar <i>et al.</i> (2006)
Nali	20.25 $\pm$ 0.18 (395)	-	-	Sharma <i>et al.</i> (2003a)
Pugal	29.62 $\pm$ 0.26 (307)	30.25 $\pm$ 0.50 (28)	28.98 $\pm$ 0.16 (279)	Dass (2006)
Sonadi	23.31 $\pm$ 0.17	-	-	Tailor <i>et al.</i> (2006)

\* Number of observation are in parenthesis

**Table 5 : Overall and sex-wise mean adult body weights (kg) in sheep**

<b>Breed</b>	<b>Overall (<math>\bar{X} \pm SE</math>) (kg)</b>	<b>Male (<math>\bar{X} \pm SE</math>) (kg)</b>	<b>Female (<math>\bar{X} \pm SE</math>) (kg)</b>	<b>Reference</b>
Balangir	-	23.60 $\pm$ 1.06	17.81 $\pm$ 0.90	Acharya and Bhat (1984)
Bannur	33.42 $\pm$ 0.53	34.80 $\pm$ 1.55	23.50 $\pm$ 0.27	Acharya and Bhat (1984)
Bannur	27.18 $\pm$ 3.61	-	-	Nagaraja <i>et al.</i> (1996)
Bandur	27.26 $\pm$ 0.26	34.38 $\pm$ 0.50	25.47 $\pm$ 0.23	Siddalinga Murthy (2001)
Bellary	-	35.39 $\pm$ 0.99	27.42 $\pm$ 0.24	Acharya and Bhat (1984)
Chokla	-	34.08 $\pm$ 1.06	23.11 $\pm$ 0.01	Acharya and Bhat (1984)
Chokla	-	34.69	28.60	Kushwaha <i>et al.</i> (1999a)
Deccani	-	42.55 $\pm$ 2.04	29.35 $\pm$ 1.60	Mali <i>et al.</i> (1985)
Deccani	-	42.00 $\pm$ 1.30	25.60 $\pm$ 1.80	Nimbkar (1993)
Deccani	31.68 $\pm$ 0.34 (52)	34.86 $\pm$ 0.60 (10)	28.5 $\pm$ 0.30 (42)	Narasimham (2002)
Ganjam	32.53 $\pm$ 0.37	33.57 $\pm$ 0.51	31.48 $\pm$ 0.82	Mishra <i>et al.</i> (2004)
Garole	10.14	-	-	Ghalasasi <i>et al.</i> (1994)
Hassan	-	25.78 $\pm$ 0.69	22.68 $\pm$ 0.18	Acharya and Bhat (1984)
Hassan	-	32.8 $\pm$ 0.85 (55)	28.3 $\pm$ 0.34 (215)	Jain <i>et al.</i> (2004)
Jaisalmeri	37.60 $\pm$ 0.17 (1272)	43.28 $\pm$ 0.30 (245)	32.05 $\pm$ 0.16 (1027)	Arora <i>et al.</i> (2005)
Kenguri	-	32.33 $\pm$ 2.57	26.69 $\pm$ 0.37	Acharya and Bhat (1984)
Local sheep	27.54 $\pm$ 0.10	28.19 $\pm$ 0.13	26.94 $\pm$ 0.01	Patro <i>et al.</i> (2006)
Madras red	-	35.54 $\pm$ 0.33	23.21 $\pm$ 0.59	Acharya and Bhat (1984)
Madras red	-	35.2 $\pm$ 0.32 (81)	23.12 $\pm$ 0.14 (256)	Raman <i>et al.</i> (2003)
Magra	-	26.85 $\pm$ 0.48	24.36 $\pm$ 0.45	Acharya and Bhat (1984)
Magra	-	27.40 $\pm$ 0.27	25.81 $\pm$ 0.45	Taneja <i>et al.</i> (1993)
Malpura	31.40	-	-	Mehta <i>et al.</i> (1995)
Mandya	25.64 $\pm$ 0.13	26.05 $\pm$ 0.41	25.5 $\pm$ 0.15	Govindaiah <i>et al.</i> (2006)

Table 5 : Contd....

Breed	Overall ( $\bar{X} \pm SE$ ) (kg)	Male ( $\bar{X} \pm SE$ ) (kg)	Female ( $\bar{X} \pm SE$ ) (kg)	Reference
Marwari	-	30.66 $\pm$ 0.46	26.18 $\pm$ 0.42	Acharya and Bhat (1984)
Mecheri	-	34.46 $\pm$ 0.66	21.59 $\pm$ 0.18	Acharya and Bhat (1984)
Mecheri	30.3 $\pm$ 0.3 (225)	34.63 $\pm$ 0.6 (63)	28.6 $\pm$ 0.2 (162)	Karunanithi <i>et al.</i> (2005)
Munjhal	-	65.93	45.37	Kushwaha <i>et al.</i> (1999b)
Muzzaffarnagri	-	50.21 $\pm$ 0.46 (53)	39.6 $\pm$ 0.03 (241)	Dinesh Kumar <i>et al.</i> (2006)
Muzzaffarnagri	42.61 $\pm$ 0.82 (180)	48.87 $\pm$ 1.84 (24)	36.75 $\pm$ 0.01 (150)	Dass and Hariprasad (2007)
Nali	-	33.27 $\pm$ 0.51	24.66 $\pm$ 0.03	Krishnappa <i>et al.</i> (1983)
Nellore	-	36.89 $\pm$ 2.56	30.00 $\pm$ 0.27	Acharya and Bhat (1984)
Nellore	37.40 $\pm$ 0.31 (32)	43.17 $\pm$ 0.57 (7)	31.24 $\pm$ 0.32 (25)	Narasimham (2002)
Pugal	39.04 $\pm$ 0.26 (254)	41.86 $\pm$ 0.45 (61)	37.22 $\pm$ 0.25 (193)	Dass (2006)
Rampur Bushair	-	34.73 $\pm$ 0.48 (115)	25.98 $\pm$ 0.49 (113)	Dixit <i>et al.</i> (2005)
Trichy black	-	25.79 $\pm$ 1.10	18.51 $\pm$ 0.18	Acharya and Bhat (1984)
Tumkur strain	20.46 $\pm$ 0.25	21.14 $\pm$ 0.45	20.46 $\pm$ 0.25	Dayananda (1998)

Note : \* Number of observation are given in parenthesis

prediction of body weights (Bhadula *et al.*, 1979; Gajbhiye and Johar, 1985; Nagaraja *et al.*, 1996; Narasimham, 2002).

The mean values of various body measurements such as chest girth, body length and height at withers recorded in various breeds at different age groups are presented in Tables 6, 7, 8, 9 and 10 respectively.

### **2.2.2.1 THREE MONTHS BODY MEASUREMENTS**

#### **2.2.2.1.1 CHEST GIRTH (CG)**

The overall mean values for chest girth of three month lambs ranged from  $29.53 \pm 0.43$  cm in Coimbatore sheep (Kandasamy *et al.*, 2006) to  $68.94 \pm 0.28$  cm in Jaisalmeri sheep (Arora *et al.*, 2007). The chest girth in ram lambs ranged from  $30.08 \pm 0.52$  cm in Coimbatore sheep (Kandasamy *et al.*, 2006) to  $59.72 \pm 1.50$  cm in Muzzafarnagari sheep (Dass and Hariprasad, 2007). Similarly in ewes, chest girth varied from  $28.98 \pm 0.48$  cm (Kandasamy *et al.*, 2006) in Coimbatore sheep to  $58.16 \pm 0.42$  cm in Muzzafarnagari breed (Mandal *et al.*, 2007).

#### **2.2.2.1.2 BODY LENGTH (BL)**

The overall highest body length of  $63.0 \pm 0.39$  cm was observed in Chokla lambs by Kushwaha *et al.* (1999a) and a lowest value of  $26.58 \pm 0.45$  cm in Coimbatore lambs was reported by Kandasamy *et al.* (2006).

In ram lambs and ewe lambs mean values ranged from  $25.19 \pm 0.55$  cm and  $25.97 \pm 0.50$  cm in Coimbatore breed (Kandasamy *et al.*, 2006) to  $57.95 \pm 0.37$  cm and  $57.39 \pm 0.37$  cm in Muzzafarnagari breed, respectively (Kushwaha *et al.*, 1999a).

**Table 6 : Overall and sex-wise mean body measurements (cm) of three months lambs reported in various breeds of sheep**

<b>Breed</b>	<b>Sex / overall</b>	<b>CG (cm)</b>	<b>BL (cm)</b>	<b>HW (cm)</b>	<b>References</b>
Bannur	Overall	52.27 ± 0.29	47.66 ± 6.22	45.42 ± 4.60	Nagaraja <i>et al.</i> (1996)
Bikaneri	Overall	62.00	40.00	58.00	Singh and Singh (1974)
Chokla	Overall	66.8 ± 0.43	60.3 ± 0.39	62.4 ± 0.36	Kushwaha <i>et al.</i> (1997)
Chokla	Overall	66.00	63.00	60.00	Kushwaha <i>et al.</i> (1999a)
Coimbatore	Overall	29.53 ± 0.43	26.58 ± 0.45 (67)	32.04 ± 0.54 (67)	Kandasamy <i>et al.</i> (2006)
	Male	30.08 ± 0.52	27.19 ± 0.55 (36)	32.39 ± 0.65 (36)	
	Female	28.98 ± 0.48	25.97 ± 0.50 (31)	31.69 ± 0.60 (31)	
Ganjam	Overall	50.80 ± 0.17	42.20 ± 0.13	46.13 ± 0.27	Mishra <i>et al.</i> (2004)
	Male	50.76 ± 0.22	42.27 ± 0.18	46.05 ± 0.36	
	Female	50.83 ± 0.25	42.12 ± 0.20	46.22 ± 0.40	
Garole	Overall	46.07 ± 0.65	36.71 ± 0.42	38.77 ± 0.46	Mishra <i>et al.</i> (2006)
	Male	47.15 ± 0.89	37.18 ± 0.61	39.94 ± 0.63	
	Female	45.08 ± 0.92	36.28 ± 0.56	39.69 ± 0.61	
Jaisalmeri	Overall	68.94 ± 0.28	58.75 ± 0.28	60.72 ± 0.26	Arora <i>et al.</i> (2007)
	Male	54.94 ± 0.38	48.09 ± 0.35	50.89 ± 0.36	
	Female	57.25 ± 0.24	50.15 ± 0.22	52.27 ± 0.23	

**Table 6 : Contd...**

<b>Breed</b>	<b>Sex / overall</b>	<b>CG (cm)</b>	<b>BL (cm)</b>	<b>HW (cm)</b>	<b>References</b>
Malpura	Overall	54.44	50.19	54.26	Basu Thakur <i>et al.</i> (1980)
Mandya	Male	44.0 ± 0.93	41.96 ± 0.77	-	Jayashankar <i>et al.</i> (2008)
	Female	45.69 ± 0.80	45.40 ± 0.85	-	
Mecheri	Overall	54.8 ± 0.3	52.0 ± 0.3	54.6 ± 0.4	Karunanithi <i>et al.</i> (2005)
	Male	54.7 ± 0.4	51.2 ± 0.4	54.0 ± 0.4	
	Female	54.8 ± 0.3	52.5 ± 0.3	53.5 ± 0.4	
Muzzafarnagari	Overall	56.82 ± 0.98	52.43 ± 0.91	57.59 ± 0.87	Dass and Hariprasad (2007)
	Male	59.72 ± 1.50	55.48 ± 1.43	60.17 ± 1.36	
	Female	53.91 ± 1.20	49.38 ± 1.14	55.00 ± 1.09	
Muzzafarnagari	Male	58.65 ± 0.48	57.95 ± 0.37	58.99 ± 0.35	Mandal <i>et al.</i> (2007)
	Female	58.16 ± 0.42	57.39 ± 0.37	58.19 ± 0.35	
Pugal	Overall	60.41 ± 0.20	50.57 ± 0.21	54.86 ± 0.17	Dass <i>et al.</i> (2004)
Rampur Bushair	Overall	49.19 ± 0.49	31.86 ± 0.32	34.82 ± 0.38	Dixit <i>et al.</i> (2005)
Sonadi	Overall	50.57 ± 0.15	47.43 ± 0.13	49.32 ± 0.12	Tailor <i>et al.</i> (2006)

### **2.2.2.1.3 HEIGHT AT WITHERS**

The overall lowest average observed for height at withers of three months lamb was  $32.04 \pm 0.54$  cm, while it was in ram lambs  $32.39 \pm 0.65$  cm and  $31.09 \pm 0.60$  cm in ewe lambs as reported by Kandasamy *et al.* (2006) in Coimbatore sheep.

The highest mean value for overall height at withers noted was  $62.4 \pm 0.36$  cm in Chokla lambs (Kushwaha *et al.*, 1997). In case of ram lambs and ewe lambs the highest mean values noted were  $60.17 \pm 1.36$  cm (Dass and Hariprasad, 2007) and  $58.19 \pm 0.35$  cm (Mandal *et al.*, 2007) respectively in Muzzafarnagari sheep.

### **2.2.2.2 SIX MONTHS BODY MEASUREMENTS**

#### **2.2.2.2.1 CHEST GIRTH (CG)**

Mishra *et al.* (2006) reported lowest pooled mean value of six months chest girth (pooled) as  $52.15 \pm 0.57$  cm, and in ram and ewe lambs as  $52.68 \pm 0.76$  cm and  $51.70 \pm 0.83$  cm, respectively, in Garole sheep.

Arora *et al.* (1975a) reported overall highest chest girth of  $84.69 \pm 0.41$  cm in Nali sheep at six month. While, in ram and ewe lambs the highest six month chest girth reported was  $74.48 \pm 0.71$  cm and  $72.12 \pm 0.81$  cm in Munjal sheep (Poonia, 2004)

#### **2.2.2.2.2 BODY LENGTH (BL)**

The mean values for body length of six month lambs in various breeds are presented in Table 7.

The overall mean values of body length of six months lambs ranged from  $37.10 \pm 0.82$  cm in Rampur Bushair (Dixit *et al.*, 2005) to  $66.24 \pm 1.66$  cm in Munjal sheep (Poonia, 2004).

**Table 7 : Overall and sex-wise mean body measurements (cm) of six months in various breeds of sheep**

Breed	Sex / overall	CG (cm)	BL (cm)	HW (cm)	References
Bannur	Overall	61.17 ± 4.03	54.96 ± 3.97	51.32 ± 2.20	Nagaraja <i>et al.</i> (1996)
Chokla	Overall	66.76 ± 0.43	60.29 ± 0.39	62.40 ± 0.36	Arora <i>et al.</i> (1975a)
Ganjam	Overall	53.23 ± 0.21	53.21 ± 0.16	55.46 ± 0.11	Mishra <i>et al.</i> (2004)
	Male	64.62 ± 0.31	53.99 ± 0.21	55.86 ± 0.14	
	Female	64.83 ± 0.35	52.47 ± 0.24	55.86 ± 0.16	
Garole	Overall	52.15 ± 0.57	41.10 ± 0.45	42.85 ± 0.44	Mishra <i>et al.</i> (2006)
	Male	52.68 ± 0.76	42.11 ± 0.65	43.76 ± 0.67	
	Female	51.70 ± 0.83	40.23 ± 0.60	42.02 ± 0.56	
Malpura	Overall	67.25 ± 0.60	62.18 ± 1.08	62.21 ± 0.54	Arora <i>et al.</i> (1975a)
Mandya	Overall	58.48 ± 0.87	51.4 ± 0.82	46.58 ± 1.0	Govindaiah <i>et al.</i> (2006)
	Male	57.09 ± 1.54	50.47 ± 1.2	44.88 ± 1.56	
	Female	59.8 ± 0.82	52.29 ± 1.11	48.19 ± 1.22	
Munjal	Overall	73.30 ± 0.74	66.24 ± 1.66	66.97 ± 1.93	Poonia , (2004)
	Male	74.48 ± 0.81	67.50 ± 1.69	68.17 ± 1.95	
	Female	72.12 ± 0.81	64.95 ± 1.69	65.77 ± 1.95	
Muzzafarnagari	Overall	61.20 ± 0.56	62.30 ± 0.49	61.60 ± 0.55	Bhadula <i>et al.</i> (1979)
Muzzafarnagari	Male	68.21 ± 0.52	66.99 ± 0.38	67.53 ± 0.35	Mandal <i>et al.</i> (2007)
	Female	66.63 ± 0.52	65.11 ± 0.39	65.59 ± 0.36	
Nali	Overall	84.69 ± 0.41	-	64.45 ± 0.38	Arora <i>et al.</i> (1975c)
Rampur Bushair	Overall	53.12 ± 0.42	37.10 ± 0.82	42.17 ± 0.55	Dixit <i>et al.</i> (2005)

In case of ram and ewe lambs lower body length values reported were  $42.11 \pm 0.11$  cm and  $40.23 \pm 0.60$  cm in Garole sheep (Mishra *et al.*, 2006). The higher values for body length at six months in ram and ewe lambs were  $67.50 \pm 1.69$  cm in Munjal sheep (Poonia, 2004) and  $65.11 \pm 0.39$  cm in Muzzafarnagari sheep (Mandal *et al.*, 2007).

#### **2.2.2.2.3 HEIGHT AT WITHERS (HW)**

The mean values for six month height at withers varied from  $42.17 \pm 0.55$  cm in Rampurbushair sheep (Dixit *et al.*, 2005) to  $67.53 \pm 0.35$  cm in Muzzafarnagari lambs (Mandal *et al.*, 2007). However, in ram and ewe lambs the six months height at withers varied from  $43.76 \pm 0.67$  cm and  $42.02 \pm 0.56$  cm in Garole lambs (Mishra *et al.*, 2006) to  $68.17 \pm 1.95$  cm and  $65.77 \pm 1.95$  cm in Munjal lambs (Poonia, 2004).

#### **2.2.2.3 NINE MONTHS BODY MEASUREMENTS**

##### **2.2.2.3.1 CHEST GIRTH (CG)**

The overall nine months chest girth varied from  $62.63 \pm 0.29$  cm in ram lambs as  $62.14 \pm 0.60$  cm and in ewe lambs  $62.68 \pm 0.32$  cm in Mecheri sheep (Anon., 2004a) to  $79.67 \pm 0.02$  cm, in ram lambs  $80.60 \pm 0.80$  cm and in ewe lambs  $78.73 \pm 0.87$  cm belonging to Muzzafarnagari sheep respectively (Dass and Hariprasad, 2007).

##### **2.2.2.3.2 BODY LENGTH**

Jagatheesan *et al.* (2003) reported overall nine month body length as  $52.48 \pm 0.19$  cm, in ram as  $54.20 \pm 0.17$  cm and in ewes as  $50.75 \pm 0.20$  cm in Mecheri sheep.

**Table 8 : Average body measurements (in cm) of nine months lambs reported in various breeds of sheep**

Breed	N	CG	BL	HW	References
Bannur	Over all	66.09± 4.02	59.20±3.94	53.64 ± 0.20	Nagaraja <i>et al.</i> (1996)
Coimbatore	Overall (147)	64.39 ± 0.51	58.8 ± 0.39	57.69 ± 0.37	Kandasamy <i>et al.</i> (2006)
	Male (37)	65.46 ± 0.65	60.30 ± 0.50	59.05 ± 0.48	
	Female (110)	63.32 ± 0.54	57.36 ± 0.42	56.32 ± 0.40	
Chokla	Females (133)	67.29 ± 0.26	61.1 ± 0.22	61.8 ± 0.24	Kushwaha <i>et al.</i> (1997)
Ganjam	Overall (80)	66.81 ± 0.23	56.08 ± 0.23	61.30 ± 0.28	Mishra <i>et al.</i> (2004)
	Male	69.20 ± 0.31	54.89 ± 0.32	63.17 ± 0.39	
	Female	63.41 ± 0.33	57.26 ± 0.34	59.43 ± 0.41	
Mecheri	Overall (1133)	64.58 ± 0.37	52.48 ± 0.19	61.54 ± 0.29	Jagatheesan <i>et al.</i> (2003)
	Male (634)	64.45 ± 0.34	54.20 ± 0.17	63.49 ± 0.28	
	Female (499)	64.70 ± 0.39	50.75 ± 0.20	59.59 ± 0.30	
Mecheri	Overall (480)	62.63 ± 0.29	58.67 ± 0.27	59.13 ± 0.32	Karunanithi <i>et al.</i> (2005)
	Male (89)	62.14 ± 0.60	57.29 ± 0.58	58.82 ± 0.62	
	Female (391)	62.68 ± 0.32	58.93 ± 0.30	59.19 ± 0.37	
Muzzafarnagari	Overall (30)	79.67 ± 0.02	87.70 ± 0.95	75.97 ± 0.86	Dass and Hariprasad (2007)
	Male (15)	80.60 ± 0.80	83.07 ± 1.35	78.87 ± 1.22	
	Female (15)	78.73 ± 0.87	80.33 ± 1.37	73.07 ± 1.48	
Sonadi	Overall	62.61 ± 0.64	59.11 ± 0.60	60.50 ± 0.58	Tailor and Yadav (2011)

Dass and Hariprasad (2007) recorded mean body length at nine months for overall, rams and ewes as  $87.70 \pm 0.95$  cm and  $83.07 \pm 1.35$  cm and  $80.33 \pm 1.37$  cm respectively in Muzzafarnagari sheep.

#### **2.2.2.3.3 HEIGHT AT WITHERS (HW)**

The lower mean values for height at withers pooled and ewes were reported as  $57.69 \pm 0.37$  cm and  $56.32 \pm 0.40$  cm respectively in Coimbatore sheep (Kandasamy *et al.*, 2006) and was  $58.82 \pm 0.62$  cm in Mecheri rams (Anon, 2004a). Whereas, Dass and Hariprasad (2007) recorded higher mean values for height at withers of nine month sheep, for pooled, rams and ewes of  $75.97 \pm 0.86$ ,  $78.87 \pm 1.22$  and  $73.07 \pm 1.48$  cm respectively in Muzzafarnagari sheep.

#### **2.2.2.4 TWELVE MONTHS BODY MEASUREMENTS**

##### **2.2.2.4.1 CHEST GIRTH (CG)**

The overall average twelve month lowest mean chest girth reported were  $60.29 \pm 0.43$  cm in rams as  $61.43 \pm 0.60$  cm (Kandasamy *et al.*, 2006) in Coimbatore sheep and  $47.6 \pm 1.0$  cm (Gupta *et al.*, 2004) in Gaddi ewes. The highest mean values for pooled, rams and ewes found were  $84.52 \pm 0.30$  cm in Nali (Arora *et al.*, 1975c),  $75.98 \pm 0.50$  and  $73.32 \pm 0.49$  cm in Muzzafarnagari (Mandal *et al.*, 2007) breeds, respectively.

##### **2.2.2.4.2 BODY LENGTH (BL)**

The lowest mean values for twelve month body length for pooled, rams and ewes were reported was  $48.68 \pm 1.12$ ,  $50.69 \pm 1.60$  and  $45.78 \pm 0.81$  cm respectively (Mishra *et al.*, 2006) in Garole sheep. Whereas higher mean values for twelve months body length reported for pooled was  $65.46 \pm 0.30$  cm in Nellore sheep (Narasimham,

**Table 9 : Overall and sex-wise mean body measurements (cm) of twelve months sheep among various breed**

<b>Breed</b>	<b>Sex / overall</b>	<b>CG (cm)</b>	<b>BL (cm)</b>	<b>HW (cm)</b>	<b>References</b>
Bannur	Overall	70.66 ± 4.62	63.56 ± 4.77	58.06 ± 2.91	Nagaraja <i>et al.</i> (1996)
Chokla	Overall	67.88 ± 0.26	61.05 ± 0.22	61.84 ± 0.24	Arora <i>et al.</i> (1975a)
Coimbatore	Overall	60.29 ± 0.43	55.85 ± 0.44	56.41 ± 0.39	Kandasamy <i>et al.</i> (2006)
	Male	61.43 ± 0.60	57.17 ± 0.61	58.16 ± 0.55	
	Female	59.16 ± 0.42	54.54 ± 0.43	54.67 ± 0.39	
Deccani (Mamidapally)	Overall	69.38 ± 0.49	63.14 ± 0.54	62.57 ± 0.51	Narasimham., (2002)
	Male	72.61 ± 0.86	65.31 ± 0.95	64.99 ± 0.89	
	Female	66.15 ± 0.48	60.96 ± 0.53	60.16 ± 0.50	
Deccani (Mahabobnagar)	Overall	67.20 ± 0.49	61.98 ± 0.38	60.66 ± 0.36	Narasimham., (2002)
	Male	69.90 ± 0.61	64.02 ± 0.48	62.46 ± 0.45	
	Female	64.79 ± 0.76	59.94 ± 0.59	58.86 ± 0.55	
Ganjam	Overall	66.82 ± 0.38	57.14 ± 0.26	62.25 ± 0.17	Mishra <i>et al.</i> (2004)
	Male	69.21 ± 0.55	58.86 ± 0.37	63.42 ± 0.27	
	Female	64.44 ± 0.53	56.21 ± 0.35	61.10 ± 0.26	

**Table 9 : Contd....**

<b>Breed</b>	<b>Sex / overall</b>	<b>CG (cm)</b>	<b>BL (cm)</b>	<b>HW (cm)</b>	<b>References</b>
Garole	Overall	61.50 ± 1.40	48.68 ± 1.12	48.95 ± 1.07	Mishra <i>et al.</i> (2006)
	Male	63.08 ± 2.16	50.69 ± 1.60	51.15 ± 1.47	
	Female	59.22 ± 1.16	45.78 ± 0.81	48.78 ± 0.74	
Malpura	Overall	67.20 ± 0.31	63.60 ± 0.37	63.80 ± 0.23	Arora <i>et al.</i> (1975a)
Mandya	Overall	65.86 ± 0.31	58.39 ± 0.76	51.25 ± 0.37	Govindaiah <i>et al.</i> (2006)
	Male	66.31 ± 0.6	67.43 ± 0.50	49.3 ± 0.67	
	Female	65.61 ± 0.35	58.31 ± 1.14	52.31 ± 0.43	
Mecheri	Overall	68.2 ± 0.2	61.9 ± 0.2	64.7 ± 0.3	Karunanithi <i>et al.</i> (2005)
	Male	71.6 ± 0.5	65.0 ± 0.5	67.91 ± 0.6	
	Female	67.3 ± 0.3	61.1 ± 0.3	63.9 ± 0.3	
Muzzafarnagari	Male	75.98 ± 0.50	74.42 ± 0.48	74.94 ± 0.47	Mandal <i>et al.</i> (2007)
	Female	73.32 ± 0.49	71.63 ± 0.48	72.17 ± 0.46	
Nali	Overall	84.52 ± 0.30	-	63.85 ± 0.27	Arora <i>et al.</i> (1975c)
Nali	Overall	61.26 ± 0.33	62.32 ± 0.39	63.49 ± 0.91	Wadyal and Balaine (1971)
Nellore (Palamaner)	Overall	67.53 ± 0.51	64.31 ± 0.43	70.5 ± 0.41	Narasimham (2002)
	Male	70.55 ± 0.85	66.93 ± 0.72	71.60 ± 0.68	
	Female	64.30 ± 0.57	61.70 ± 0.48	69.42 ± 0.45	
Sonadi	Overall	70.74 ± 0.77	64.70 ± 0.68	65.49 ± 0.45	Tailor and Yadav (2011)

2002), while in rams and ewes higher mean values of  $74.42 \pm 0.48$  cm and  $71.63 \pm 0.48$  cm respectively were recorded in Muzzafarnagari sheep (Mandal *et al.*, 2007).

#### **2.2.2.4.3 HEIGHT AT WITHERS (HW)**

The average values reported for height at withers ranged from  $48.95 \pm 1.07$  cm for pooled group,  $51.15 \pm 1.47$  cm for rams and  $48.78 \pm 0.74$  cm for ewes in Garole sheep (Mishra *et al.*, 2006) to  $72.24 \pm 0.27$  cm in Nellore sheep (Narasimham, 2002) for pooled, and to  $74.94 \pm 0.47$  cm and  $72.17 \pm 0.46$  cm, respectively, in Muzzafarnagari rams and ewes (Mandal *et al.*, 2007).

#### **2.2.2.5 ADULT SHEEP BODY MEASUREMENTS**

##### **2.2.2.5.1 CHEST GIRTH (CG)**

The overall mean values of adult chest girth ranged from  $67.9 \pm 0.26$  cm in Chokla sheep (Kushwaha *et al.*, 1997) to  $85.06 \pm 0.91$  cm in Muzzafarnagari sheep (Dass and Hariprasad, 2007).

In rams and ewes the lowest mean values of adult chest girth reported were  $44.00 \pm 0.75$  and  $43.69 \pm 0.59$  cm respectively in Garole sheep (Arora *et al.*, 2005). The highest mean value for chest girth of rams was  $82.38 \pm 0.35$  cm in Muzzafarnagari sheep (Dass and Hariprasad, 2007).

##### **2.2.2.5.2 BODY LENGTH (BL)**

The lowest mean values of adult BL reported for pooled, rams and ewes were  $49.60 \pm 0.14$  cm in Deccani sheep (Sreenivasu *et al.*, 2003), and  $45.78 \pm 0.70$  cm and  $42.97 \pm 0.60$  cm respectively in Garole sheep (Arora *et al.*, 2005).

**Table 10 : Overall and sex-wise mean body measurements (cm) of adult sheep in various of breeds**

<b>Breed</b>	<b>Sex / overall</b>	<b>CG (cm)</b>	<b>BL (cm)</b>	<b>HW (cm)</b>	<b>References</b>
Bannur	Overall	72.64 ± 0.21	59.60 ± 0.14	53.52 ± 0.25	Siddalinga Murthy. (2001)
	Male	76.44 ± 0.41	61.67 ± 0.26	56.99 ± 0.23	
	Female	71.45 ± 0.19	57.53 ± 0.12	55.5 ± 0.11	
Bellary	Male (152)	82.5 ± 0.42	70.2 ± 0.3	74.5 ± 0.32	Jain <i>et al.</i> (2005)
	Female (591)	76.1 ± 0.17	65.6 ± 0.14	68.9 ± 0.13	
Chokla	Overall	68.00 ± 0.43	61.52 ± 0.40	61.75 ± 0.27	Arora <i>et al.</i> (1975a)
Chokla	Overall	67.9 ± 0.26	61.1 ± 0.22	61.8 ± 0.27	Kushwaha <i>et al.</i> (1997)
Coimbatore	Overall (153)	73.43 ± 0.42	65.01 ± 0.46	64.04 ± 0.37	Kandasamy <i>et al.</i> (2006)
	Male (34)	77.49 ± 0.65	68.42 ± 0.70	67.20 ± 0.60	
	Female (119)	69.37 ± 0.39	61.60 ± 0.43	60.89 ± 0.37	
Deccani	Overall	73.96 ± 0.21	49.69 ± 0.14	65.03 ± 0.19	Sreenivasu <i>et al.</i> (2003)
Deccani	Overall	74.2 ± 0.43	67.12 ± 0.45	64.67 ± 0.54	Narasimham (2002)
	Male	77.01 ± 0.74	69.05 ± 0.77	65.29 ± 0.93	
	Female	74.41 ± 0.42	65.19 ± 0.44	64.11 ± 0.53	

**Table 10 : Contd...**

<b>Breed</b>	<b>Sex / overall</b>	<b>CG (cm)</b>	<b>BL (cm)</b>	<b>HW (cm)</b>	<b>References</b>
Garole	Overall	77.04 ± 0.35	67.17 ± 0.21	67.38 ± 0.29	Mishra <i>et al.</i> (2004)
	Male	79.53 ± 0.49	67.29 ± 0.30	68.07 ± 0.33	
	Female	74.56 ± 0.49	67.07 ± 0.30	66.69 ± 0.33	
Garole	Male	59.62 ± 1.52	45.78 ± 0.70	44.0 ± 0.75	Arora <i>et al.</i> (2005)
	Female	55.91 ± 1.19	42.97 ± 0.60	43.69 ± 0.59	
Hassan	Male (55)	75.3 ± 0.71	64.3 ± 0.04	64.4 ± 0.61	Jain <i>et al.</i> (2006)
	Female (215)	72.0 ± 0.36	62.0 ± 0.21	60.8 ± 0.23	
Indigenous sheep (kendrapada)	Overall	70.68 ± 0.20	53.22 ± 0.38	51.67 ± 0.25	Patro <i>et al.</i> (2006)
	Male	72.90 ± 0.19	56.25 ± 0.29	52.43 ± 0.25	
	Female	70.14 ± 0.09	52.58 ± 0.5	51.50 ± 0.13	
Jaisalmeri	Overall	81.70 ± 0.20	69.48 ± 0.21	69.56 ± 0.21	Arora <i>et al.</i> (2007)
	Male	83.94 ± 0.33	71.78 ± 0.38	71.65 ± 0.28	
	Female	79.95 ± 0.17	67.17 ± 0.19	67.46 ± 0.15	
Malpura	Overall	69.06 ± 0.37	64.99 ± 0.37	64.41 ± 0.35	Arora <i>et al.</i> (1975b)
Mandya	Overall	74.19 ± 0.17	61.96 ± 0.16	51.34 ± 0.37	Govindaiah <i>et al.</i> (2006)
	Male	74.50 ± 0.34	62.59 ± 0.35	51.81 ± 0.49	
	Female	74.08 ± 0.19	61.75 ± 0.17	57.17 ± 0.47	

**Table 10 : Contd..**

<b>Breed</b>	<b>Sex / overall</b>	<b>CG (cm)</b>	<b>BL (cm)</b>	<b>HW (cm)</b>	<b>References</b>
Mecheri	Overall	73.8 ± 0.4	65.5 ± 0.4	67.4 ± 0.4	Karunanithi <i>et al.</i> (2005)
	Male	80.0 ± 0.6	70.9 ± 0.6	71.1 ± 0.5	
	Female	71.0 ± 0.6	63.1 ± 0.5	65.7 ± 0.5	
Muzzafarnagari	Male	84.32 ± 0.81	80.32 ± 0.81	80.68 ± 0.68	Dinesh Kumar <i>et al.</i> (2006)
	Female	78.51 ± 0.29	73.53	73.59 ± 0.25	
Muzzafarnagari	Overall	85.06 ± 0.49	82.93 ± 0.46	83.87 ± 0.42	Dass and Hariprasad (2007)
	Male	87.75 ± 0.91	86.54 ± 0.86	87.58 ± 0.78	
	Female	82.38 ± 0.35	79.31 ± 0.34	80.17 ± 0.31	
Nali	Overall	85.17 ± 0.48	-	64.81 ± 0.42	Arora <i>et al.</i> (1975b)
Nellore	Male	72.16 ± 0.93	66.79 ± 0.80	72.57 ± 0.93	Narasimham (2002)
	Female	70.12 ± 0.53	66.10 ± 0.50	72.19 ± 0.53	
Pugal	Overall	73.73 ± 0.09	66.74 ± 0.08	66.33 ± 0.08	Tailor <i>et al.</i> (2006)
Pugal	Overall (2135)	71.83 ± 0.20	61.59 ± 0.31	61.76 ± 0.17	Dass (2007)
	Male (478)	73.63 ± 0.26	63.20 ± 0.43	62.88 ± 0.11	
	Female (1658)	70.04 ± 0.19	59.58 ± 0.23	60.65 ± 0.16	
Rampurbushair	Male	79.63 ± 0.49	52.56 ± 0.58	58.68 ± 0.30	Dixit <i>et al.</i> (2005)
	Female	75.99 ± 0.38	50.34 ± 0.71	53.93 ± 0.45	
Tumkur strain	Overall	65.26 ± 0.39	56.76 ± 0.29	55.18 ± 0.25	Dayananda (1998)

The highest mean values of adult BL for pooled, rams and ewes reported were  $82.93 \pm 0.46$ ,  $86.54 \pm 0.82$  and  $79.31 \pm 0.34$  cm respectively in Muzzafarnagari sheep (Dass and Hariprasad, 2007).

#### **2.2.2.5.3 HEIGHT AT WITHERS (HW)**

The lowest mean value of adult height at withers reported for rams and ewes are  $44.00 \pm 0.75$  and  $43.69 \pm 0.59$  cm in Garole sheep (Arora *et al.*, 2005) and that of pooled was  $51.34 \pm 0.37$  cm in Mandya sheep (Govindaiah *et al.*, 2006).

The highest mean values for adult height at withers reported for pooled, rams and ewes are  $82.93 \pm 0.46$ ,  $86.54 \pm 0.86$  and  $79.31 \pm 0.34$  cm respectively in Muzzafarnagari sheep (Dass and Hariprasad, 2007).

### **2.3 EFFECT OF NON-GENETIC FACTORS ON BODY WEIGHT IN SHEEP**

#### **2.3.1 SEX OF LAMB**

##### **2.3.1.1 THREE MONTHS WEIGHT**

Several studies have indicated that males were significantly heavier than females at their three months body weight. This sexual dimorphism has been well documented in various breeds of sheep by Kulkarni and Deshpande (1986b) and Naikare and Jagtap (1989) in Deccani, Kaila *et al.* (1989) and Mandal *et al.* (2003) in Muzzafarnagari lambs, Kumar *et al.* (1989) in UAS strain of sheep, Mehta *et al.* (2003) in Magra, Dass (2006) in Pugal lambs, Nehra and Singh (2006) in Marwari and Waghmode *et al.* (2008) in Madgyal sheep. However, Jayashankar *et al.* (2008) reported ewe lambs were heavier than ram lambs in Mandya breed.

However, the effect of sex of lamb on three months body weight was found to be non-significant as reported in Muzzafarnagari lambs by Bhadula and Bhat (1980a), in Magra breed by Mehta *et al.* (2003) and in Marwari lambs by Nehra and Singh (2006).

### **2.3.1.2 SIX MONTHS WEIGHT**

Irrespective of the breed of sheep, sex had significant effect on weight of lambs at six months. Bhadula and Bhat (1980a), Kulkarni and Deshpande (1986b), Naikare and Jagtap (1988), Kaila *et al.* (1989), Dixit *et al.* (2001), Dinesh Kumar *et al.* (2006), Mandal *et al.* (2003), Dass (2007) and Waghmode *et al.* (2008) reported significant effect of sex on six month body weight. Non-significant effect of sex of lamb was reported by Narayanaswamy *et al.* (1975) in Mandya breed, Arora *et al.* (1975c) in Nali and Chokla and Singh and Prakash (1986) in Gaddi breed of sheep. Jayashankar *et al.* (2008) reported that at six months female lambs were heavier in Mandya breed.

### **2.3.1.3 NINE MONTHS WEIGHT**

Significant effect of sex of lamb on weight at nine months was reported in Muzzafarnagari (Bhadula and Bhat, 1980a; Kaila *et al.*, 1989; Mandal *et al.*, 2003), Ganjam and Balangir by Mohanty and Mishra (1992), Kheri and Malpura by Sushil Kumar *et al.*, (2003), Magra by Mehta *et al.* (2003), Marwari sheep by Nehra and Singh (2006) and in Madgyal sheep by Waghmode *et al.* (2008). In contrary to the above findings Narayanaswamy *et al.* (1975) reported that sex had no influence on nine months body weight in Mandya sheep. Similarly Arora *et al.* (1983) also observed no influence of sex on body weights at nine months in Nali and Chokla breeds.

#### **2.3.1.4 TWELVE MONTHS WEIGHT**

Significant effect of sex on yearling weight have been reported by Malik *et al.* (1970) in Magra, Kaila *et al.* (1989) and Mandal *et al.* (2003) in Muzzafarnagari, Dixit *et al.* (2001) in Bharat Merino, Dass (2006) in Pugal, Nehra and Singh (2006) in Marwari, Patro *et al.* (2006) in indigenous, Arora *et al.* (2007) in Jaisalmeri and Waghmode *et al.* (2008) in Madgyal breeds of sheep. However, Narayanaswamy *et al.* (1975) noticed non-significant influence on yearling weight in Mandya sheep. While Jayashankar *et al.* (2008) concluded ewes were heavier than ram in Mandya sheep at this age.

#### **2.3.1.5 ADULT BODY WEIGHT**

Significant influence of sex on adult body weight were recorded in Coimbatore sheep by Singh and Mathur (1971), in Nali by Krishnappa *et al.* (1983), in Deccani by Nimbkar (1993), in Karakul by Sahani *et al.* (1993), in Tumkur strain by Dayananda (1998), in Bandur by Siddalinga Murthy (2001), in Jaisalmeri by Arora *et al.* (2007) and by Narasimham (2002) in Nellore and Deccani sheep. Krishna Reddy and Rai (1987) observed that males were heavier than females, probably due to faster growth of males than females. However, no significant different due to sex was reported by Singh and Singh (1974) in Bikaneri Breed.

### **2.3.2 LOCATION (DISTRICT)**

#### **2.3.2.1 THREE MONTH**

Significant effect of location ( $P \leq 0.01$ ) was reported by Arora *et al.* (2007) on three months weight in Jaisalmeri sheep in Jaisalmer, Barmer and Jodhpur districts of Rajasthan. Balasubramanyam and Kumaraswamy (2011) and Patro *et al.* (2006)

reported non-significant effect of location on three months weight in Madras Red sheep and Indigenous sheep of Orissa, respectively.

#### **2.3.2.2 SIX MONTH**

Location significantly ( $P \leq 0.01$ ) affected six months weight in Jaisalmeri sheep as investigated by Arora *et al.* (2007). Similarly, significant effect of location was reported by Boujenane and Kerfal (1990) in D'Man lambs raised at Errachidia and Achouria areas of Morocco. Balasubramanyam and Kumaraswamy (2011) and Tailor and Yadav (2011) reported significant influence of district on six month weight in Madras Red and Sonadi sheep respectively.

#### **2.3.2.3 NINE MONTH**

Balasubramanyam and Kumaraswamy (2011) and Tailor and Yadav (2011) reported significant effect of district / centre on nine month weight in different breeds of sheep. Similar findings were also observed by Arora *et al.* (2007) in Jaisalmeri sheep .

#### **2.3.2.4 TWELVE MONTH**

Significant influence of place of sheep on twelve months weight was noted by Sreenivasu *et al.* (2003) in Deccani sheep, Arora *et al.* (2007) in Jaisalmeri sheep. Balasubramanyam and Kumaraswamy (2011) and Tailor and Yadav (2011) noticed significant influence of place on twelve months weight in Madras Red and Sonadi sheep respectively.

#### **2.3.2.5 ADULT SHEEP**

Sreenivasu *et al.* (2003) in Deccani and Arora *et al.* (2007) in Jaisalmeri sheep and Tailor and Yadav (2011) in Sonadi sheep noticed significant influence of Mandal and localities on body weight of adult sheep.

### **2.3.3 EFFECT OF NON-GENETIC FACTORS ON BODY MEASUREMENTS**

#### **2.3.3.1 SEX OF LAMB**

##### **2.3.3.1.1 THREE MONTHS**

Highly significant influence of sex of lamb on three months chest girth, body length and height at withers was reported by Mishra *et al.* (2004) indicating greater chest girth and height in Ganjam sheep. Patro *et al.* (2006) reported significant influence of sex on all the three body measurement of three month old lambs. Significant influence were also noticed by Mandal *et al.* (2007) and Dass and Hariprasad (2007) in Muzzafarnagari sheep.

In contrary to the above reports, Mishra *et al.* (2006) noticed sex of lamb had no influence on all the three measurements in three month old Garole lambs. Jayashankar *et al.* (2008) reported higher body measurements for ewe lambs of Mandya breed.

##### **2.3.3.1.2 SIX MONTHS**

Mandal *et al.* (2007) and Dass and Hariprasad (2007) reported highly significant ( $P \leq 0.01$ ) effect of sex on all the three body measurements on six month lamb of Muzzafarnagari breed. Mishra *et al.* (2006) also reported significant ( $P \leq 0.05$ ) effect of sex of lamb on chest girth and height at withers in Ganjam sheep but not on body length. Patro *et al.* (2006) noticed significant influence of sex of lamb on all three body measurements of indigenous sheep of Kendrapada area.

Arora *et al.* (2007) reported that sex of lamb had no effect on chest girth, body length and height at withers among Jaisalmeri lambs.

#### **2.3.3.1.3 NINE MONTHS**

Mishra *et al.* (2004) noticed significant influence of sex of lamb on chest girth, body length and height at withers of Ganjam lambs. Similarly, Mandal *et al.* (2007) and Arora *et al.* (2007) noticed significant effect of sex of lamb on all the three measurements in Muzzafarnagari and Jaisalmeri sheep respectively. Similar significant effect on all three body measurements was reported by Dass and Hariprasad (2007) in Muzzafarnagari sheep.

However Mishra *et al.* (2006) reported non-significant effect of sex of lamb on chest girth and other body measurements.

#### **2.3.3.1.4 TWELVE MONTHS**

The significant influence of sex on body measurements (CG, BL, HW) of twelve month sheep was reported by Siddalinga Murthy (2001) in Bannur, Arora *et al.* (2007) in Jaisalmeri, Mandal *et al.* (2007), Dass and Hariprasad (2007) in Muzzafarnagari sheep respectively. Narasimham (2002) reported similar significant effect in Deccani and Nellore sheep.

Heart girth was found to be not influenced by sex of lamb by Mishra *et al.* (2006) in Garole sheep, whereas CG and BL were significantly influenced by sex of sheep at twelve months.

#### **2.3.3.1.5 ADULT SHEEP**

In Coimbatore breed, all the adult body measurements were indicative of significant effect of sex ( $P \leq 0.05$ ) expressing ram as taller, longer and stouter (Kandasamy *et al.*, 2006). Highly significant influence of sex of sheep was also noticed in Jaisalmeri sheep on CG, BL and HW (Arora *et al.*, 2007).

Similar to above reports, significant effect of sex of sheep on body measurements was reported in Deccani (Narasimham, 2002), in Pugal (Dass, 2007) and Muzzafarnagari sheep (Dass and Hariprasad, 2007).

### **2.3.3.2 PLACE / DISTRICT**

#### **2.3.3.2.1 THREE MONTH**

Arora *et al.* (2007) reported significant effect of location on body measurements on three month old Jaisalmeri sheep. Tailor and Yadav (2011) also observed significant influence of district of sheep on three month body measurement in Sonadi breed.

#### **2.3.3.2.2 SIX MONTH**

Tailor and Yadav (2011) reported significant effect of district on six month weight in Sonadi breed. However, non-significant influence of place of sheep was observed by Arora *et al.* (2007) on body measurements in Jaisalmeri sheep, and by Patro *et al.* (2006) in Indigenous sheep, while.

#### **2.3.3.3 NINE MONTH**

Boujenane and Kerfal (1990) noticed significant effect of place (location) on nine month body measurements of D'Man sheep of Morocco. Tailor and Yadav (2011) also noticed significant effect of district of sheep on body measurements of nine months Sonadi sheep.

#### **2.3.3.4 TWELVE MONTH**

Sreenivasu *et al.* (2003), Arora *et al.* (2007) and Tailor and Yadav (2011) reported significant effect of location on yearly body measurements indicating difference in environments and managerial conditions resulting in higher growth in Deccani, Jaisalmeri and Sonadi sheep respectively.

### **2.3.3.5 ADULT SHEEP**

Sreenivasu *et al.* (2003), Patro *et al.* (2006), Arora *et al.* (2007) and Tailor and Yadav (2011) noticed significant influence of location on adult body measurement of various breeds of sheep.

## **2.4 REPRODUCTIVE TRAITS**

Regular reproduction is an important component of flock productivity; especially, it is a serious limiting factor in indigenous breeds of sheep. Non-genetic factors considered here are only for place / location / mandal / district effect on different reproductive traits

### **2.4.1 AGE AT FIRST LAMBING (AFL)**

Age at first lambing is an important economic trait in sheep. Ability to produce first lamb at an earlier age leads to reduced generation interval, increase in number of lambs produced in lifetime in turn decreased expenditure on ewe during maiden stage.

The mean values of AFL recorded in different breeds of sheep are presented in table 11.

The overall AFL ranged from  $360 \pm 30.0$  days in Garole breed (Ghalasasi and Nimbkar, 1993) to  $1149 \pm 0.50$  in Deccani breed as reported by Nimbkar (1993).

#### **2.4.1.1 LAMBING INTERVAL (LI)**

Lambing at regular and comparatively shorter intervals is an essential feature of rapid multiplication of the outstanding genetic material produced through various breeding methods or plans.

**Table 11 : Means and standard errors of age at first lambing (days) in different breeds of sheep**

<b>Breed</b>	<b>Average lambing interval (days)</b>	<b>References</b>
Balangir	608 ± 7.80	Mohanty and Mishra (1992)
Bandur	650 ± 16.00	Narayanaswamy <i>et al.</i> (1976)
Bandur	707.85 ± 5.70	Siddalingamurthy (2001)
Chokla	970 ± 18.0	Kushwaha <i>et al.</i> (1997)
Deccani	1149 ± 0.50	Nimbkar (1993)
Ganjam	593.00 ± 8.00	Mohanty and Mishra (1992)
Garole	360 ± 30.0	Ghalasasi and Nimbkar (1993)
Indigenous sheep	518.67 ± 0.81	Patro <i>et al.</i> (2006)
Mandya	917.10 ± 43.20	Purushotham (1972)
Mandya	977.54 ± 51.49	Krishna Reddy <i>et al.</i> (1984)
Mandya	898.00 ± 53.90	Ramesh Gupta and Krishna Reddy (1986)
Mandya	645.45 ± 26.08	Rai <i>et al.</i> (1988)
Mecheri	529 ± 0.1	Karunanithi <i>et al.</i> (2005)
Munjhal	530.53 ± 12.39 (69)	Poonia (2008)
Nellore	943.00 ± 29.70	Reddy (1980)
Nellore	941.00 ± 29.70	Krishna Reddy <i>et al.</i> (1984)
Pugal	271.0 ± 0.07	Dass (2007)
Sonadi Overall	709.67 ± 38.0	Tailor <i>et al.</i> (2007)
Udaipur	723.03 ± 11.16	
Chittargar	642.42 ± 16.45	
Rajsamand	705.39 ± 14.06	
Bhilwara	767.83 ± 15.81	

**Table 12 : Means and standard errors of lambing interval (days) in different breeds of sheep**

<b>Breed</b>	<b>Mean lambing interval (days)</b>	<b>References</b>
Balangir	341.00 ± 4.20	Mohanty and Mishra (1992)
Bandur	304.42 ± 11.00	Narayanaswamy <i>et al.</i> (1976)
Bandur	331.71 ± 3.55	Siddalingamurthy (2001)
Deccani	433.50	Nimbkar (1993)
Ganjam	327.00 ± 4.00	Mohanty and Mishra (1992)
Garole	240.00	Ghalasasi and Nimbkar (1993)
Indigenous sheep	214.01 ± 0.33	Patro <i>et al.</i> (2006)
Malpura	372.58	Arora and Swarnakar (1995)
Mandya	378.40 ± 5.70	Ramesh Gupta and Krishna Reddy (1986)
Mandya	284.27 ± 0.21	Rai <i>et al.</i> (1988)
Mecheri	529.01	Karunanithi <i>et al.</i> (2005)
Munjál	247.66 ± 4.88	Poonia (2008)
Nellore	406.89	Purushotham (1972)
Nellore	398.30 ± 15.56	Krishna Reddy <i>et al.</i> (1984)
Pugal	283.13 ± 0.95	Dass (2007)
Sonadi (overall)	275.08 ± 4.22	Tailor <i>et al.</i> (2007)
Udaipur	279.41 ± 3.49	
Chittargar	269.87 ± 6.26	
Rajalmond	282.53 ± 5.40	
Bhilwara	270.49 ± 5.87	

The mean values of lambing interval reviewed in various breeds of sheep are presented in Table 12.

The overall LI varied between 240 days in Garole sheep (Ghalasasi and Nimbkar, 1993) to  $529 \pm 0.1$  days in Mecheri sheep (Karunanithi *et al.*, 2005).

## **2.4.2 EFFECT OF NON-GENETIC FACTORS ON AGE AT FIRST LAMBING**

### **2.4.2.1 AGE AT FIRST LAMBING**

Significant effect of localities on AFL was reported in Sonadi sheep of Rajasthan by Tailor *et al.* (2007). But, Patro *et al.* (2006) reported non-significant effect of area of sheep on AFL.

### **2.4.2.2 EFFECT OF NON-GENETIC FACTOR ON LAMBING INTERVAL**

Significant effect of place / localities on LI was recorded in indigenous breed of Kendrapada area and Marshaghai blocks of Orissa state (Patro *et al.*, 2006). Tailor *et al.* (2007) found no significant effect of districts on lambing interval of Sonadi breed of Rajasthan.

## **2.5 HERITABILITY ESTIMATES**

Genetic parameters play a vital role in formulation of breeding plans for livestock improvement.

Heritability of a character is important to a breeder, since it represents the proportion of gain which is transmitted to the offspring through selected parents. The heritability estimates in this study are of body weights at various age groups reviewed are detailed in Tables 13, 14, 15 and 16.

### **2.5.1 THREE MONTH WEIGHT**

The heritability estimates ranged in indigenous breeds from  $0.03 \pm 0.05$  in Nali sheep as reported by Sharma *et al.* (2003a) to  $0.89 \pm 0.18$  in Kashmir Merino sheep (Shiekh *et al.*, 1986).

### **2.5.2 SIX MONTH WEIGHT**

The heritability estimates reported for six months body weight of Indian breeds ranged from  $0.08 \pm 0.09$  in Marwari sheep (Nehra and Singh, 2006) to  $0.84 \pm 0.12$  in Nali sheep as reported by Sharma *et al.* (2003a) respectively. In exotic sheep it was reported as  $0.28 \pm 0.10$  by Dzakuma *et al.* (1978).

### **2.5.3 NINE MONTH WEIGHT**

Bhadula and Bhat (1980) reported heritability for nine months body weight as  $0.08 \pm 0.40$  in Muzzafarnagari. Iyue (1993) noted a higher heritability value of  $0.58 \pm 0.06$  in Nilagiri synthetic.

### **2.5.4 TWELVE MONTH WEIGHT**

The heritability estimates for twelve months body weight ranged from  $0.08 \pm 0.09$  in Marwari sheep (Nehra and Singh, 2006) to  $0.64 \pm 0.06$  in Nilgiri synthetic (Iyue, 1993) as reported in Indian sheep. In exotic breeds heritability values varied from  $0.11 \pm 0.11$  in Hampshire (Dzakuma *et al.*, 1978) to  $0.82 \pm 0.26$  in Rambouillet sheep (Bassett *et al.*, 1967).

**Table 13 : Estimates of heritability with standard error of three months body weight for different breeds of sheep**

Breed	No.	$h^2 \pm SE$	Reference
Avikalin Model 2 Model 8		0.26 0.25	Maroof Ahmad <i>et al.</i> (2005)
Bharat Merino		$0.14 \pm 0.06$	Dixit <i>et al.</i> (2001)
Bikaneri	545	$0.68 \pm 0.26$	Dass and Acharya (1970)
Nali	523	$0.29 \pm 0.10$	Acharya and Malik (1971)
Nali	226	$0.29 \pm 0.10$	Arora <i>et al.</i> (1975c)
Bannur	-	$0.18 \pm 0.10$	Urala (1977)
Hissardale		$0.16 \pm 0.03$	Akthar <i>et al.</i> (2007)
Kashmir Merino		$0.89 \pm 0.18$	Sheikh <i>et al.</i> (1986)
Malpura		$0.49 \pm 0.05$	Mishra <i>et al.</i> (2009)
Muzzafarnagri		$0.43 \pm 0.12$	Singh and Singh (1997)
Muzzafarnagri		$0.18 \pm 0.02$	Mandal <i>et al.</i> (2003)
Nali		$0.03 \pm 0.05$	Sharma <i>et al.</i> (2003a)
Nilagiri		$0.16 \pm 0.08$	Panneerselvam (1993)
Nilagiri		$0.15 \pm 0.05$	Rajendran (2005)
Nilagiri Synthetic		$0.49 \pm 0.09$	
Pattanwadi	24	$0.68 \pm 0.63$	Daflapurkar <i>et al.</i> (1980)
Pattanwadi x Deccani	78	$0.44 \pm 0.22$	
<b>Exotic breeds</b>			
Deccani Ramlamb Ewelamb	467 319	$0.23 \pm 0.03$ $0.49 \pm 0.05$	Kulkarni and Deshpande (1986a)
Dorset half bred Ramlamb Ewelamb		$0.23 \pm 0.05$ $0.62 \pm 0.06$	Kulkarni and Deshpande (1986b)
Merino half bred Ramlamb Ewelamb		$0.45 \pm 0.02$ $0.17 \pm 0.13$	
Corridale	100	$0.62 \pm 0.52$	Krishnappa (1979)
Corridale		$0.21 \pm 0.10$	Kumar and Tomar (1982)
Chilos		$0.36 \pm 0.12$	Mavrogenis <i>et al.</i> (1980)
D'Man		$0.52 \pm 0.10$	Boujenane and Kerfal (1990)
Grozney Merino		$0.63 \pm 0.25$	Mani <i>et al.</i> (1982)
Hampshire		$-0.09 \pm 0.06$	Dzakuma <i>et al.</i> (1978)

**Table 14 : Estimates of heritability for six months weight ( $\pm$ S.E.) in different breeds of sheep**

<b>Breed</b>	<b><math>h^2 \pm</math> S.E.</b>	<b>References</b>
<b>Indian breeds</b>		
Avikalin (different models)	0.365	Maroof Ahmad <i>et al.</i> (2004)
	0.37	
	0.16	
Bharat Merino	$0.52 \pm 0.09$	Dixit <i>et al.</i> (2001)
Bharat Merino	$0.20 \pm 0.08$	Swain <i>et al.</i> (2004)
Bikaneri (Magra strain)	$0.37 \pm 0.09$	Chopra and Acharya (1971)
Deccani - Ewe lambs	$0.30 \pm 0.04$	Kulkarni and Despande (1986b)
Deccani - Ram lambs	$0.29 \pm 0.03$	Kulkarni and Despande (1986b)
Malpura	$0.78 \pm 0.02$	Mishra <i>et al.</i> (2009)
Marwari	$0.08 \pm 0.09$	Nehra and Singh (2006)
Muzzafarnagri	$0.18 \pm 0.31$	Bhadula and Bhat (1980b)
Muzzafarnagri	$0.27 \pm 0.09$	Singh and Singh (1997)
Muzzafarnagri	$0.19 \pm 0.03$	Mandal <i>et al.</i> (2003)
Nali	$0.51 \pm 0.26$	Arora <i>et al.</i> (1975c)
Nali	$0.84 \pm 0.12$	Sharma <i>et al.</i> (2003a)
Nellore	$0.56 \pm 0.16$	Reddy <i>et al.</i> (1983)
Nilagiri	$0.39 \pm 0.13$	Panneerselvam (1993)
Nilagiri Synthetic	$0.60 \pm 0.05$	Iyue (1993)
Pattanwadi	$0.18 \pm 0.56$	Daflapurkar <i>et al.</i> (1980)
Pattanwadi	$0.10 \pm 0.13$	Shah and Patel (1989)
<b>Exotic breeds</b>		
Hampshire	$0.28 \pm 0.10$	Dzakuma <i>et al.</i> (1978)

**Table 15 : Estimates of heritability for nine months weight ( $\pm$ S.E.) in different breeds of sheep**

<b>Breed</b>	<b><math>h^2 \pm</math> S.E.</b>	<b>References</b>
<b>Indian breeds</b>		
Deccani ewe lambs	$0.26 \pm 0.05$	Kulkarni and Despande (1986b)
Malpura	$0.28 \pm 0.08$	Mishra <i>et al.</i> (2009)
Marwari	$0.13 \pm 0.10$	Nehra and Singh (2006)
Muzzafarnagri	$0.08 \pm 0.40$	Bhadula and Bhat (1980b)
Muzzafarnagri	$0.16 \pm 0.03$	Mandal <i>et al.</i> (2003)
Nali	$0.33 \pm 0.26$	Arora <i>et al.</i> (1975c)
Nellore	$0.17 \pm 0.10$	Reddy <i>et al.</i> (1983)
Nilagiri	$0.68 \pm 0.19$	Panneerselvam (1993)
Nilagiri Synthetic	$0.58 \pm 0.06$	Iyue (1993)
Pattanwadi	$0.18 \pm 0.56$	Daflapurkar <i>et al.</i> (1980)
<b>Exotic breeds</b>		
Southdown	$0.18 \pm 0.02$	Kirmani <i>et al.</i> (1986)
Dorset-half bred	$0.25 \pm 0.03$	Kurkarni and Deshpande (1986b)
Merino - half bred	$0.56 \pm 0.02$	Kurkarni and Deshpande (1986b)

**Table 16 : Estimates of heritability for twelve months weight ( $\pm$ S.E.) in different breeds of sheep**

Breed	$h^2 \pm$ S.E.	References
<b>Indian breeds</b>		
Avikalin	$0.36 \pm 0.37$	Maroof Ahmad <i>et al.</i> (2004)
Bharat Merino	$0.51 \pm 0.09$	Dixit <i>et al.</i> (2001)
Bharat Merino	$0.24 \pm 0.09$	Swain <i>et al.</i> (2004)
Deccani ewe lambs	$0.43 \pm 0.05$	Kulkarni and Despande (1986b)
Kashmir Merino	$0.48 \pm 0.12$	Sheikh <i>et al.</i> (1986)
Malpura	$0.28 \pm 0.08$	Mishra <i>et al.</i> (2009)
Marwari	$0.08 \pm 0.09$	Nehra and Singh (2006)
Muzzafarnagri	$0.26 \pm 0.04$	Mandal <i>et al.</i> (2003)
Nali	$0.15 \pm 0.24$	Arora <i>et al.</i> (1975c)
Nellore	$0.10 \pm 0.09$	Reddy <i>et al.</i> (1983)
Nilagiri	$0.53 \pm 0.17$	Panneerselvam (1993)
Nilagiri Synthetic	$0.64 \pm 0.06$	Iyue (1993)
Pattanwadi	$0.45 \pm 0.08$	Daflapurkar <i>et al.</i> (1980)
<b>Exotic breeds</b>		
Rambouillet	$0.82 \pm 0.26$	Bassett <i>et al.</i> (1967)
Rombouillet	$0.57 \pm 0.15$	Ercanbrack and Price (1972)
Targhee	$0.25 \pm 0.10$	
Columbia	$0.55 \pm 0.14$	
Hampshire	$0.11 \pm 0.11$	Dzakuma <i>et al.</i> (1978)
Scottish blackface	$0.21 \pm 0.28$	Atkins (1986)

## 2.6 CORRELATIONS AMONG BODY WEIGHT AND BIOMETRICAL MEASUREMENTS

Basu Thakur *et al.* (1967) observed highly significant correlations ( $P < 0.01$ ) between weight and length (0.70); body weight and height (0.65) and height and hock (0.60) in Gaddi ewes, whereas the correlations between girth and hip (0.31); height and canon (0.32) and height and hip (0.28) were significant ( $P \leq 0.05$ ).

Basu Thakur and Negi (1968) found positive and significant correlations between body weight and length at 2-teeth (0.85); body weight and height at withers at the age of 2-teeth (0.57) and 4-teeth (0.77); and body weight and girth at the age of 2-teeth (0.70) and 4-teeth (0.78) in Rampur Bushair ewes. Significant correlations of 0.54 ( $P \leq 0.05$ ) were observed between body length and body height at 2-teeth. The correlation coefficient between length and girth was 0.57 and between height and girth was 0.55 respectively. The coefficient of correlation between length and height (0.27) was significant ( $P \leq 0.05$ ).

Bhasin *et al.* (1968) found positive and significant phenotypic correlations of body weight with girth (0.66), length (0.39) and height at withers (0.69) in Bikaneri sheep.

Basu Thakur and Singh (1969) studied the relationship between body weight and body measurements in Coimbatore and Corriedale sheep and found that in both the breeds, the correlation coefficients between body weight and all the body measurements were highly significant, except that for hock. Simple correlation coefficients of body weight with other body measurements in Corriedale and Coimbatore Sheep are presented below.

Correlation coefficient between body weight and body measurements in  
Coimbatore and Corriedale sheep

Body weight with measurement	“r” value	
	Corriedale	Coimbatore
Length	0.566	0.803
Girth	0.664	0.957
Height	0.483	0.393
Brisket	0.415	0.529
Hip	0.552	0.369
Canon	0.424	0.393
Hock	0.159	0.064

Malik *et al.* (1970) reported positive but not significant relationship between the body weight and body measurements in Magra lambs. Correlation coefficient between the body length and body weight was 0.04 in males and 0.55 in females; between height at withers and body was 0.17 in males.

Singh *et al.* (1972) observed positive and significant phenotypic correlation coefficients ( $P \leq 0.05$ ) of body weight with length (0.79), height and withers (0.75) and girth (0.95), while the correlations between body length with height and girth were 0.725 and 0.86, respectively, and the correlation between height and girth was 0.84, in Bikaneri ewes.

Ghanekar *et al.* (1973) reported the phenotypic correlation coefficients between body length and height in  $\frac{1}{2}$  Patanwadi sheep at 2 and 4 teeth age as 0.29 and 0.42, between length and girth as 0.29 and 0.38, and between height and girth as 0.63 and 0.62 respectively. Similarly the correlation coefficients between body length and

height in 3/4<sup>th</sup> Patanwadi sheep at 2 and 4 teeth age were 0.74 and 0.76, between length and girth were 0.63 and 0.83 and between height and girth were 0.60 and 0.78 respectively. All the correlations were found to be significant.

Singh and Singh (1974) reported positive and significant ( $P < 0.01$ ) phenotypic correlations of body weight with length (0.82), height at withers (0.81) and with girth (0.85) in Bikaneri lambs.

Arora *et al.* (1977) found positive and significant correlations of body weight with heart girth (0.54), length (0.48) and height at withers (0.30) and between heart girth and body length (0.51) in Sonadi ewes.

Mahajan and Bohra (1977) observed positive and significant phenotypic correlations ( $P < 0.01$ ) of body weight with body length (0.68), heart girth (0.71) and height at withers (0.47) in Gaddi sheep.

Basu Thakur *et al.* (1980) reported significant correlations of body weight with body length (0.61), height at withers (0.45), heart girth (0.71) and cannon bone length (0.35) in Malpura lambs.

Bhadula *et al.* (1980) reported positive and significant phenotypic correlations among the body weights and body measurements at different ages in Muzaffarnagari lambs and the coefficient of correlations ranged from 0.39 to 0.94. Body weight was highly correlated with various body measurements (0.52 to 0.93).

Khan and Bhat (1981) reported the phenotypic correlations in Muzaffarnagari sheep and its half breeds with Corriedale. The correlations of body weight at 6 months age with body length, heart girth, paunch girth and chest width were 0.80, 0.77, 0.76 and 0.39, respectively. The correlations between body length and body height and

heart girth were 0.68, 0.76 and 0.79 and between body height and heart girth were 0.67 and 0.63, respectively.

Kandasamy and Gupta (1983) reported the correlation coefficients of body weight with body length, height and heart girth as 0.82, 0.76 and 0.81, respectively in Nali and 0.62, 0.81 and 0.82 respectively in Chokla breeds. All the correlations were significant ( $P < 0.01$ ).

Gajbhiye and Johar (1985) reported positive and significant correlations in Magra sheep. The correlations between body weight and body length, height at withers, heart girth and hip width were 0.74, 0.78, 0.86 and 0.79; between body length and height at withers, heart girth and hip width were 0.64, 0.68 and 0.63; and between height at withers and heart girth and hip width were 0.71 respectively.

Siddalinga Murthy (2001) reported correlation coefficients of body weights and body measurement in Bandur sheep as highly significant and positively correlated with height at withers (0.582), body length (0.660), chest girth (0.682) and paunch girth (0.658). Correlation of height at wither with body length was 0.66 and with chest girth was 0.59.

Narasimham (2002) reported that the correlation coefficients of body weight with biometrical measurements in 2 teeth males and females ranged from 0.15 to 0.61 at the age of 2-teeth and also reported that the correlation of different biometrical measurements in males and females ranged from -0.01 to 0.67 at the age of 2 teeth in Deccani sheep. The worker also reported that correlations between body weight and biometrical measurements at the age of 2 teeth in both sexes ranged from -0.21 to 0.92 for the Nellore sheep at L.R.S., Chintaladevi; 0.55 to 0.91 for the Nellore sheep at C.L.F., Chintaladevi and 0.27 to 0.84 at L.R.S., Palamaner.

Vimal Selvaraj *et al.* (2002) reported that correlation of body weights with body measurements of 3, 6, 9 and 12 months age Madras red sheep was moderate to high i.e., correlation of body weight with body length, height, chest girth and paunch girth for 6 months was  $0.82 \pm 0.12$ ,  $0.83 \pm 0.13$ ,  $0.88 \pm 0.10$  and  $0.54 \pm 0.3$ , and for 12 months was  $0.45 \pm 0.19$ ,  $0.33 \pm 0.21$ ,  $0.80 \pm 0.13$  and  $0.46 \pm 0.1$ , respectively.

The simple correlation coefficients obtained between body weights and biometrical measurements was highly significant ( $P < 0.01$ ) as reported by Ramanareddy *et al.* (2002) in Deccani sheep. The coefficient of correlation between body weight of adult sheep with heart girth, height at withers and body length were 0.883, 0.770 and 0.752 respectively.

Sreenivasu *et al.* (2003) reported highly significant coefficient of correlation of 0.67, 0.42 and 0.42 between body weight (2 teeth) and heart girth, body length and height at withers, respectively, while correlation estimates among body measurement were also highly significant and positive for chest girth with body length and height at withers (0.50 and 0.51, respectively). Correlation of body length with height at withers was 0.33 and highly significant.

Afolayan *et al.* (2006) reported that in Yankasa breed, live weight was very highly ( $P < 0.01$ ) correlated with body dimensional traits (0.76 to 0.94), and of the body dimensional traits, girth was most related trait to weight and the correlation between these two traits was 0.94. Variables such as height and length which are directly related to the size and weight of sheep showed correlation of 0.84 and 0.76 respectively.

## 2.7 PREDICTION OF BODY WEIGHT BASED ON BODY MEASUREMENTS

Wadyal and Balaine (1971) suggested the following prediction equations for estimating the body weight from body measurements in Nali and Lohi breeds.

Breed	Equation
Nali ewes ( $R^2 = 44\%$ )	$Y = A + 0.40X_1 + 0.07X_2 + 0.04X_3 + 0.15X_4$
Lohi ewes ( $R^2 = 56\%$ )	$Y = A + 0.18X_1 + 0.29X_2 + 0.38X_3 - 0.11X_4$

Where,

Y = body weight; A = over all mean;  $X_1$  = body weight deviated from mean

$X_2$  = height at withers deviated from mean;  $X_3$  = heart girth deviated from mean

$X_4$  = paunch girth deviated from mean

Bhadula *et al.* (1979) fitted the regression equations for predicting the body weight from various body measurements at different ages in Muzaffarnagari sheep which are presented as below.

Age (weeks)	Multiple regression equation	$R^2$ (%)
4	$Y = -2.11 + 0.06X_2 + 0.06X_4 + 0.03X_7 + 0.08X_8 + 0.08X_9$	48.70
8	$Y = -7.57 + 0.14X_2 + 0.04X_6 + 0.08X_7 + 0.23X_9$	62.00
12	$Y = -11.65 + 0.20X_2 + 0.10X_5 + 0.07X_7 + 0.24X_9$	71.30
16	$Y = -21.70 + 0.04X_2 + 0.15X_3 + 0.21X_5 + 0.12X_6 + 0.27X_8 + 0.23X_9$	85.40
20	$Y = -23.25 + 0.16X_3 + 0.51X_4 + 0.20X_6 + 0.49X_8$	80.00
24	$Y = -29.33 + 0.42X_2 + 0.33X_6 + 0.58X_9$	82.00
28	$Y = -29.48 + 0.20X_2 + 0.32X_6 + 0.65X_8 + 0.38X_9$	87.70
32	$Y = -31.03 + 0.20X_3 + 0.34X_4 + 0.40X_6 + 0.86X_8 + 0.52X_9$	91.60

Where Y = Estimated body weight (kg); X<sub>2</sub> = Body length from shoulder to point pin bone (cm); X<sub>3</sub> = Withers height (cm); X<sub>4</sub> = Chest depth (cm); X<sub>5</sub> = Chest girth (cm); X<sub>6</sub> = Paunch girth (cm); X<sub>7</sub> = Round the hip (cm); X<sub>8</sub> = Shoulder width (cm); X<sub>9</sub> = Sternum length

h (cm)

Bhat *et al.* (1980) developed following Step-down regression equations for the prediction of body weight (Y) at different age groups based on biometrical measurements in Muzaffarnagari sheep.

Equation	R <sup>2</sup> (%)
$Y_0 = -1.97 + 0.15 X_1$	35.00
$Y_4 = -6.65 + 0.31 X_1$	38.00
$Y_8 = -9.84 + 0.28 X_1 + 0.11 X_3$	50.00
$Y_{13} = -15.34 + 0.28 X_1 + 0.24 X_3$	78.00

Where,

Y<sub>0</sub>, Y<sub>4</sub>, Y<sub>8</sub>, Y<sub>13</sub> = body weight at birth 4, 8 and 13 weeks of age, respectively

X<sub>1</sub> = body length (cm)

X<sub>3</sub> = heart girth (cm)

Kandasamy and Gupta (1983) constructed prediction equations for body weight in Nali and Chokla breeds of sheep and they are presented as below.

Breed	Prediction equation	R <sup>2</sup> (%)
Nali	$Y = -12.78 + 0.24X_1 + 0.05X_2 + 0.11X_3 + 0.55X_4$	87.00
Chokla	$Y = -20.36 + 0.19X_1 + 0.08X_2 + 0.21X_3 + 0.19X_4$	89.00
Rambouillet x Nali	$Y = -19.34 + 0.11X_1 + 0.13X_2 + 0.14X_3 + 0.18X_4$	86.00
Soviet Merino x Nali	$Y = -14.21 + 0.04X_1 + 0.20X_2 + 0.13X_3 + 0.10X_4$	80.00
Rambouillet x Chokla	$Y = -17.48 + 0.18X_1 + 0.14X_2 - 0.00X_3 + 0.22X_4$	90.00
Soviet Merino x Chokla	$Y = -20.64 + 0.22X_1 + 0.04X_2 + 0.17X_3 + 0.16X_4$	87.00

Where Y = predicted body weight (kg); X<sub>1</sub> = body length (cm); X<sub>2</sub> = height (cm);  
X<sub>3</sub> = heart girth (cm); X<sub>4</sub> = paunch girth (cm)

Gajbhiye and Johar (1985) developed the prediction equation for estimating the body weight from various body measurements in Magra sheep.

$$Y = -45.42 + 0.40X_1 + 0.30X_2 + 0.64X_3 + 0.20X_4 \quad (R^2 = 84.44\%)$$

Where Y = predicted body weight (kg); X<sub>1</sub> = body length (cm); X<sub>2</sub> = height (cm);  
X<sub>3</sub> = heart girth (cm); X<sub>4</sub> = paunch girth (cm)

Pradhan (1987) formulated the following equation for predicting body weight from body measurements in sheep.

$$W = \frac{BC^2}{12.00}$$

Where W = Body weight; B = Body length (cm); C = Heart girth (cm)

Warris and Edwards (1995) developed the following equation for estimating the body weight from heart girth in adult sheep.

$$\text{Live weight (kg)} = [(\text{Heart girth in cm} \times 0.03) + 0.89]^3$$

Nagaraja *et al.* (1996) developed multiple regression equations for predicting body weights in Bannur sheep by using the linear body measurements as

Equation	R <sup>2</sup> (%)
$Y_3 = 8.63 - 0.63 X_1 + 0.54 X_2$	31.36
$Y_6 = 58.20 + 0.85 X_1 + 0.54 X_2$	90.18
$Y_9 = -24.67 + 0.43 X_1 + 0.34 X_2$	54.54
$Y_{12} = -24.29 + 0.61 X_1 + 0.07 X_3$	21.60

Where  $Y_3$ ,  $Y_6$ ,  $Y_9$ ,  $Y_{12}$  are body weights at birth 3, 6, 9 and 12 months of age and  $X_1$  = body length (cm);  $X_2$  = heart girth (cm)

Vimal Selvaraj *et al.* (2002) constructed simple regression equations in Madras Red sheep using regression coefficients of the body weight on four body measurements in 3, 6, 9 and 12 months aged sheep and reported maximum confluence of the calculated and the actual body weight values by the measurements of chest girth, body length, height and paunch girth.

Ramanareddy *et al.* (2002) developed multiple regression equations by step-up procedure in Deccani sheep to find out the reliability of prediction of body weight by including hearth girth ( $X_1$ ), height at withers ( $X_2$ ) and body length ( $X_3$ ) as independent variables and the body weight ( $Y$ ) as dependent variable. As per their findings, best prediction equation for above one year old Deccani sheep was obtained, when all the three body measurements were fitted in the equation(88.73)

	R <sup>2</sup> (%)
$Y = -25.85 + 0.778X_1$	77.93
$Y = -38.60 + 0.5818X_1 + 0.439X_2$	85.60

$$Y = -41.08 + 0.544X_1 + 0.224X_2 + 0.30X_3 \quad 88.73$$

Narasimham (2002) constructed step down multiple regression equation for predicting body weights in Nellore sheep and Deccani sheep of 2 teeth, 4 teeth rams and ewes and reported as below.

Age	Sex	Regression equation	R <sup>2</sup> value (%)
<b>Nellore sheep</b>			
2-teeth	Ram	$Y = -83.46 + 0.64^{**}X_1 + 0.68^{**}X_2 + 0.43^{*}X_3 - 0.52X_4$	94.29
		$Y = -85.43 + 0.60^{**}X_1 + 0.65^{**}X_2 + 0.39^{*}X_3$	94.09
2-teeth	Ewe	$Y = -49.74 + 0.63^{**}X_1 + 0.33^{**}X_2 - 0.05X_3 + 0.80X_4$	87.30
		$Y = -49.86 + 0.62^{**}X_1 + 0.34^{**}X_2 + 0.79^{*}X_4$	87.30
<b>Deccani sheep</b>			
2-teeth	Ram	$Y = -53.16 + 0.19X_1 + 0.12X_2 + 0.23X_3 + 2.46X_4$	66.12
		$Y = -44.45 + 0.20X_1 + 0.21X_2 + 2.45X_4$	61.70
2-teeth	Ewe	$Y = -29.56 + 0.21X_1 + 0.03X_2 + 0.12X_3 + 1.70^{**}X_4$	54.06
		$Y = -28.94 + 0.22X_1 + 0.13X_2 + 1.73^{**}X_4$	53.80
		$Y = -28.94 + 0.30X_1 + 1.84^{**}X_4$	52.30

He concluded that best prediction equation obtained when all the four body measurements were entered the equation where  $r^2$  value was high in all ram and ewe groups.

Afolayan *et al.* (2006) used step-up multiple regression equations to predict body weight of yearlings to over 3 years Yankasa breed of sheep of Nigeria and reported that sheep height with hip width appeared to be important variable along

with chest girth to obtain up to 91 per cent prediction of body weight. The equations developed were as following:

<b>Variable</b>	<b>Intercept</b>	<b>b<sub>1</sub></b>	<b>b<sub>2</sub></b>	<b>b<sub>3</sub></b>	<b>b<sub>4</sub></b>	<b>b<sub>5</sub></b>	<b>R<sup>2</sup></b>
Gh	-30.55	0.75	-	-	-	-	0.88
Gh + Hp	-33.61	0.69	0.37	-	-	-	0.90
Gh + Hp + Ht	-38.31	0.57	0.41	0.23	-	-	0.91
Gh + Hp + Ht + Lh	-39.75	0.50	0.49	0.17	0.18	-	0.91

Where Gh = heart girth; Hp = hip width; Ht = body height and Lh = body length



# **MATERIALS AND METHODS**

## **III MATERIAL AND METHODS**

### **3.1 MATERIALS / SOURCE OF DATA**

The data for the present study on morphological characters, body weights, body measurements and reproduction traits were collected from Bandur sheep maintained in its breeding / home tract in selected taluks of Mandya, Mysore, Bangalore (Rural) and Kolar districts of Karnataka (Fig 1).

A detailed stratified random sampling of farmer's household intensive survey was conducted involving 116 villages distributed in 13 taluks of four districts viz., Mandya, Mysore, Bangalore (Rural) and Kolar (Table 17).

The data pertaining to 3210 sheep on morphological, body weights, body measurements and reproductive traits like inter lambing period and age at first lambing were recorded from December 2004 to December 2005 on Bandur sheep from the four districts.

### **3.2 GEOGRAPHICAL LOCATION AND CLIMATOLOGICAL FEATURES OF THE BREEDING TRACT**

The breeding tract falls into two agro-climatic zones of the state viz., eastern dry zones (Zone-5) and southern dry zone (Zone-6) i.e., Zone-5 consisting of Bangalore rural and Kolar districts and Zone-6 comprising of Mysore and Mandya districts. Eastern dry zone (Zone-5) is located at an altitude of mean elevation ranging from 1500 mt above mean sea level. The major area ranging from 800 to 900 meter above the mean sea level and at a longitude range between 77° to 79° and latitude range of 13° to 14.52° North.

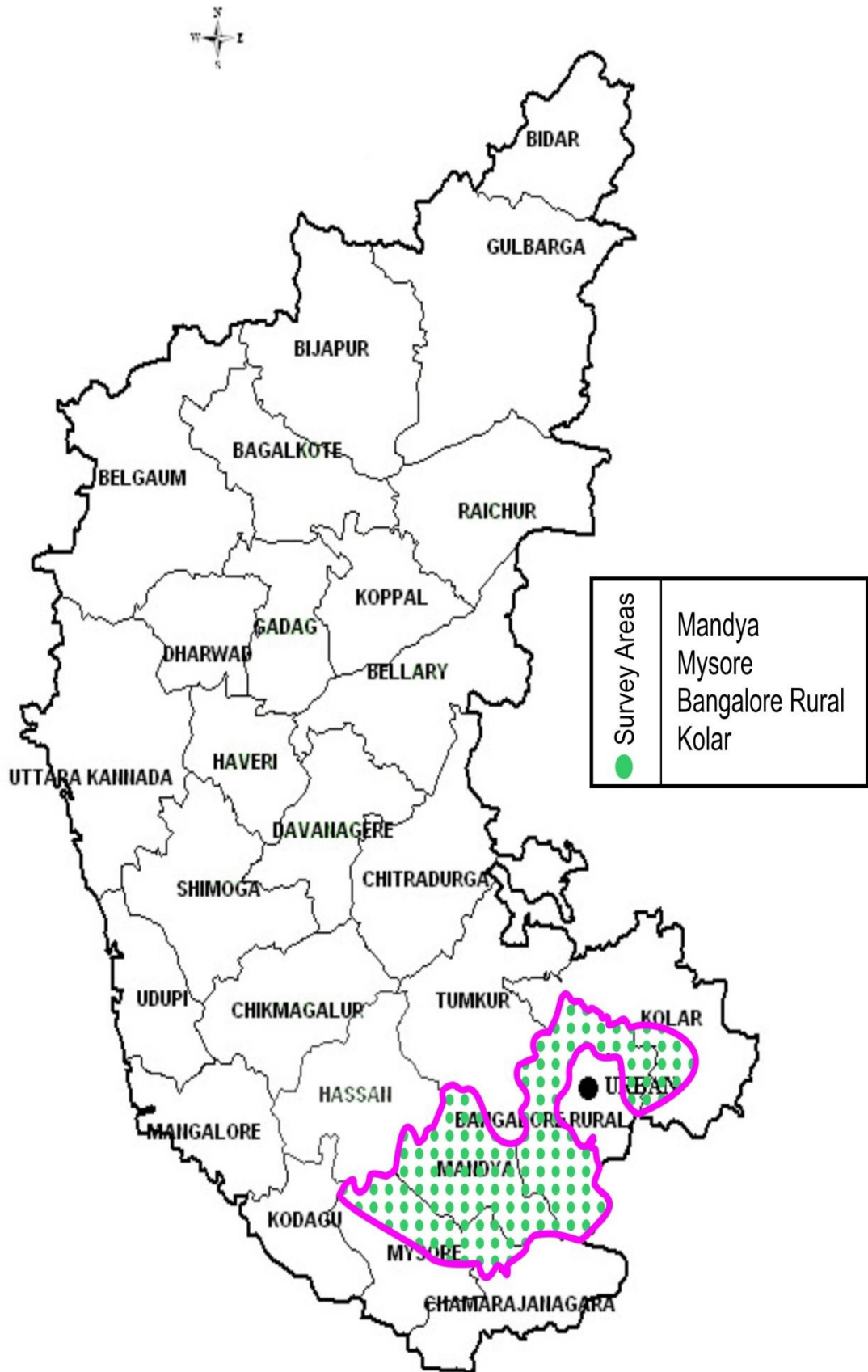


Fig. - 1 Survey area of Bandur sheep in home tract

**Table 17 : Taluk wise number of villages covered in each district for detail stratified random survey of Mandya sheep**

<b>Mandya</b>		<b>Mysore</b>		<b>Bangalore (Rural)</b>		<b>Kolar</b>	
<b>Taluk</b>	<b>No. of villages</b>	<b>Taluk</b>	<b>No. of villages</b>	<b>Taluk</b>	<b>No. of villages</b>	<b>Taluk</b>	<b>No. of villages</b>
Mandya	5	T.Narsipura	12	Channapatna	5	Kolar	14
Malavalli	16	K.R.Nagara	20	Kanakapura	2	-	-
Maddur	9	-	-	Magadi	3	-	-
Pandavapura	12	-	-	-	-	-	-
K.R. Pete	6	-	-	-	-	-	-
Nagamangala	1	-	-	-	-	-	-
S.R. Patna	11	-	-	-	-	-	-
<b>Sub-total</b>	<b>60</b>		<b>32</b>		<b>10</b>		<b>14</b>

The average rainfall observed in the survey area Zone-5 ranges from 680 to 890 mm over five years and in the year of survey (2005) annual mean rainfall recorded was 776 mm, with an highest of 155 mm bring recorded in the month of September 2005.

The range of minimum and maximum temperature of the three seasons recorded during the period of March to June, July to October and November to February was 18.9°C to 33.5°C, 19.1°C to 28.5°C and 15.2°C to 29.6°C, respectively. Relative humidity ranged from a minimum of 39.5 per cent in March to a mzximum of 73.5 per cent in the month of July.

Zone-6 / Southern dry zone is located at an altitude of mean elevation ranging from 450 to 900 meters above mean sea level. The major area of survey is situated at 800 to 900 meters above mean sea level and at a longitude range between 77° to 79°, with an latitude range of 13° to 14.52° North.

The rainfall in the major area of survey ranges from 670 mm to 890 mm and annual mean rainfall recorded was 734 mm for the year 2005 and the maximum rainfall recorded was 153 mm in the month of October.

The range of minimum and maximum temperature of the three seasons observed during the period of March to June, July to October and November to February (2005) was 20.20°C to 33.6°C, 18.3°C to 28°C and 16.4°C to 30.9°C, respectively.

The relative humidity ranged from a minimum of 48.5 per cent in the months of February and March (2005) to a maximum of 81.0 per cent in the month of July (2005).

### **3.3 SHEEP HUSBANDRY PRACTICES / MANAGERIAL PRACTICES**

#### **3.3.1 GRAZING SYSTEMS**

In the Bandur sheep breeding tract, sheep were normally raised under **sedentary / pastoral system** (grazing system) in majority of the districts. Partial grazing and confinement system of production was also followed in the canal irrigated areas of Mandya and Mysore districts and is called as **tethering** system.

Pastoral system of rearing sheep ensured the improvement of the dry-land ecology through grazing all kinds of shrubs, and also improved the soil fertility by their droppings and urine.

Tethering production system was also practiced partially in the intensive irrigated areas, wherein 2 to 5 sheep were being tied at one place to a peg or tree / bushy plants. The sheep were fed with cultivated fodder / grass / tree toppings from morning to mid day and later on allowed for grazing in the open fields. Landless sheep rearers generally adopted this system which emerges as notable sub-system of sheep farming at present.

#### **3.3.2 FEEDING PRACTICES**

In the breeding tract, normally supplemental feeding of grains / concentrate mix is not practiced in the flock in general. Few farmers, especially small and landless farmers, were found to practice supplemental feeding of breeding rams, expectant and nourishing mothers and young lambs, with broken and crushed maize, horsegram, green gram etc., and hulls of the red gram / green gram / cowpea which was fed at a rate of 50 g to 150 g per day per head. Normally, sheep were grazed in the early morning and afternoon for duration of 8 to 10 hrs perday as a routine pastoral system of management of sheep.

The sheep farmers, practicing tethering system of production, fed the sheep with roughages in the form of green fodder, foliage, tree toppings, sugarcane tops and vegetable leftovers in the range of 0.5 kg to 1.5 kg at different time intervals as supplemental feeding in addition to grazing in on common property resources, harvested fields, cultivable waste lands etc. It was also noticed that some farmers hand fed the sheep at a rate of 1.5 kg per sheep per day during late evening or night and these animals were also sent for grazing during day time.

### **3.3.3 HOUSING PATTERN**

Majority of sheep sheds were of pucca type ranging from 58 per cent in Kolar district to maximum of 83 per cent in Bangalore (Rural) district, wherein sheep were housed within the backyard or within the corner of dwelling houses of farmers for obvious reasons of security to sheep. In closed type of housing, a separate enclosure / cage type structure is created within the house for housing of young lambs. In open type of sheds / housing, there was no shelter and sheep were exposed to vagaries of nature viz., sunlight, rains and winds all through day and night. Majority of farmers provided shelter to sheep at night times, so that sheep were protected from theft or attack by predators. A marginal number of farmers provided housing / shelter facilities both day and night in the entire breeding tract.

### **3.4 BREEDING MANAGEMENT**

Selection of breeding ram was done prior to breeding season on the basis of body size and condition, conformation and breed characters. The ram aged above one and a half years was used for first breeding. Breeding rams were provided succulent green fodder including legumes and concentrates at a rate of 200 g per day per ram.

Normally rams were culled from the flock once in every 2 to 3 years of breeding to avoid inbreeding. No selection was made in case of ewes, and all the ewes in the flock were retained for breeding on the basis of their body size, conformation and breed characters, fertility status and mothering ability. All the physically deformed, infertile rams and ewes were eliminated from the breeding stock. The ewes were provided with supplemental feeding of concentrate mixture or crushed grains and green fodder for 2 to 3 weeks prior to mating at a rate of 100 g to 250 g per day per ewe in order to bring them in good condition for breeding as a part of flushing. Ewes aged above 12 months and already lambed and which had completed 60 to 90 days of lactation and expressing heat symptoms were allowed for flock mating (or hand mating by the trained personnel).

Breeding was carried out twice during the year from March to April (Season-1) and from September to October (Season-2). The most favoured breeding season was season-1 and less favoured season was being season-2. As per information collected, lambing percentage of 50-55 per cent took place in most favourable season falling between September and October months and around 25 per cent in the months of March and April.

Selective breeding was practiced in a limited way, followed by flock mating system. Breeding rams were allowed for mating during night and morning hours in the flock. The pregnant ewes were separated one month before lambing from the flock and housed in lambing pens. They were provided with succulent green fodder and concentrates at the rate of 100 g per day per ewe. This additional feeding was provided till the new born lambs were weaned.

Lambs were allowed to suckle and remain with their dams up to three months of age and weaned thereafter. The dams up to three months from the lambing date were kept separately in a group and grazed close to the corrals with a view to bring them back to shed at noon for suckling their young lambs. Ram lambs were disposed for breeding at younger age and ewe lambs were added to main flock as replacement stock. Sheep were periodically culled at the age of seven to eight years irrespective of their production abilities and due to other abnormalities which rendered them uneconomical to maintain in the flock.

### **3.5 SHEARING PRACTICES**

Bandur sheep in the breeding tract were shorn twice in a year from July to August and from December to January. Usually hand shearing was practiced and later, machine shearing was made available in the local veterinary dispensaries with the co-operation of State Sheep and Wool Development Board.

### **3.6 SHEEP HEALTH MANAGEMENT / CONTROL MEASUREMENT**

Sheep were regularly vaccinated against the prevalent diseases namely, foot and mouth (twice a year), sheep pox, enterotoxaemia, PPR and Haemorrhagic septicaemia once in a year. Sheep were dewormed to control endoparasitic load once in three to four months interval. Deworming was periodically carried out by Karnataka Sheep and Wool Development Board using broad spectrum parasiticides. To get rid of external parasites, sheep were dipped twice annually. In addition, regularly health coverage was ensured to all sheep as and when required. All the pens were sprayed with acaricides twice a year and each pen was kept empty at least fifteen days in a year to avoid external parasitic problems. Also, few of the farmers used



**Fig . 2 Fifteen days old Bandur lambs**



**Fig . 3 three month old Bandur lamb**

traditional disinfectant methods of smoking and spraying of home made insecticides to control ectoparasitic infestation control.

### 3.7 TYPE OF DATA

The traits considered and recorded in the present study were as follows:

1. Morphological traits.
2. Body weights at different ages.
3. Body measurements at different ages and
4. Reproductive traits.

The description of the morphological traits and definitions of the body measurements recorded in this study are given below.

#### 3.7.1 MORPHOLOGICAL CHARACTERS

The descriptions of morphological characters are as follows

##### Description of morphological traits

<b>Trait</b>	<b>Type</b>
Coat colour	White with brown face/Dull white with brown face / Light brown
Forehead	Convex / concave / strait
Tassel / wattle	Presence / absence
Beard condition	Presence / absence
Tail shape	Curved / straight
Tail length	Short / medium
Presence of horn	Present / absent
Horn colour	Black / white / brown
Horn shape	Straight / curved
Ear orientation	Horizontal / pendulous / erect



**Fig . 4 Bandur Ram (2 teeth )**



**Fig . 5 Bandur Ram (4 teeth )**

### 3.7.2 BODY WEIGHTS AND BODY MEASUREMENTS

The sheep were weighed at different ages using a sensitive dial type weighing balance to the nearest 50 g. Body measurements were recorded to the nearest centimeter, before the sheep were let out for grazing. Measurements were taken on the live sheep after making the sheep to stand squarely on even floor surface, by using a measuring tape. Sheep was secured by an attendant with its head a little high in a normal position as suggested by Turner *et al.* (1953) and measurements were recorded as detailed below.

#### Definition of body measurements

	Measurements	Description
A	Chest Girth	Circumference of chest just behind the point of elbow
B	Body length	Oblique distance from the wither to the pin bone (Point of buttock)
C	Height at withers	From the highest point of wither vertically to the ground

### 3.7.3 REPRODUCTIVE TRAITS

The data collected on reproductive traits pertained to 1004 lambings for age at first lambing, and 868 lambing records information for lambing intervals.

### 3.8 CLASSIFICATION OF DATA

The data on body weight and measurements were grouped into four districts (as mentioned below) as per data collected / recorded to study the effect of location on all the mentioned traits.

1. Mandya (D<sub>1</sub>)
2. Mysore (D<sub>2</sub>)
3. Bangalore Rural (D<sub>3</sub>)
4. Kolar (D<sub>4</sub>)



**Fig . 6 Bandur ewe (4 teeth )**



**Fig . 7 Ewe with suckling lamb**



**Fig . 8 Typical fore head and nose of Bandur sheep**



**Fig . 9 Typical fore head and nose of Bandur sheep without wattles**

Data on morphological traits, body weights and body measurement were classified into two sex groups i.e. male ( $S_1$ ) and female ( $S_2$ ). The classification details are presented in Table-18.

Data were also classified into five age groups based on order of teeth eruption and wear and tear shape of feet. Since the information on date of birth of each of sheep was not available, hence the age of the sheep was determined by pattern of teeth eruption and dentition as recorded by the farmers.

<b>Age group</b>	<b>Dentition</b>
0-3	4 Milk teeth
3-6	All temporary incisors (4 <sup>th</sup> pre molar appears)
6-9	All temporary incisors
9-12	Wear and tear of milk teeth (replacement of central pair of incisors)
1½ - 2 yrs 3 months	Second set of incisors (4 teeth)
3 years	Third set of incisors (6 teeth)
4 <sup>th</sup> year	Fourth set of corner incisors (8 teeth)

(Kaushish, 1994; John.B.O, 1976)

Data of adult sheep above one year was grouped into male and female and numbers were counted for variations in the morphological features as listed.

Further, data for body weights and body measurements were grouped into five age groups they are as below (3210):

1. 3 months ( $\leq 3$ )
2. 6 months ( $\leq 6$ )
3. 9 months ( $\leq 9$ )
4. 12 months ( $\leq 12$ )
5. Adults ( $\geq 12$ )

**Table 18 : Classification of data (number of observations)**

Age group district	3 months		6 months		9 months		12 months		Adults	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Mandya (D <sub>1</sub> )	14	17	18	30	76	171	186	81	60	318
Mysore (D <sub>2</sub> )	12	17	28	24	81	145	119	46	85	399
Bangalore (D <sub>3</sub> )	60	66	16	18	27	56	73	29	24	103
Kolar (D <sub>4</sub> )	9	25	-	-	5	13	272	129	14	244
Total (sex-)	95	125	62	72	189	385	650	283	183	1064
<b>Total</b>	<b>220</b>		<b>134</b>		<b>574</b>		<b>933</b>		<b>1247</b>	

### 3.9 STATISTICAL METHOD

#### 3.9.1 PERCENTAGE COMPUTATION

The data pertaining to morphological traits of adults were grouped into different sex. Using standard procedures percentage of sheep in each group expressing typical listed character were computed.

#### 3.9.2 LEAST SQUARES ANALYSIS OF VARIANCE

Data recorded in the present study consisted of unequal sub-class frequencies, thus leading to non-orthogonality. To overcome non-orthogonality of data, the least square analysis of variance for disproportionate sub-class frequencies as suggested by Harvey (1987) was followed to detect the significant sources of non-genetic variation. The following fixed effect model was used for analysis.

##### a. For body weight and body measurements

$$Y_{ijk} = \mu + D_i + S_j + C_{ijk}$$

Where  $Y_{ijk}$  = The record of the  $k^{\text{th}}$  individual belonging to the  $i^{\text{th}}$  district of  $j^{\text{th}}$  sex group.

$\mu$  = population mean

$D_i$  = fixed effect of  $i^{\text{th}}$  district group ( $I = 1, 2, 3, 4$ )

$S_j$  = fixed effect of  $J^{\text{th}}$  sex group ( $J = 1, 2$ )

$C_{ijk}$  = random error associated with  $Y_{ijk}$  and assumed to be identically, independently and normally distributed with mean zero and the unit variance and no interaction between various effects.

### 3.9.2.1 ESTIMATION OF LEAST SQUARE CONSTANTS AND MEANS

The method of least squares analysis involved four major steps.

1. Setting up of normal equations(a matrix of frequencies) and reduction of the equations.
2. Inversion of frequency matrix.
3. Estimation of least squares mean for the different effects.
4. Least squares analysis of variance.

A set of least squares normal equations were developed as outlined by Harvey (1987)

The matrices were reduced after imposing the following restrictions.

$$\sum D_i = \sum S_j = 0$$

The resultant matrix equation obtained was;  $\underline{C} \cdot \underline{b} = \underline{Y}$

Where  $\underline{C}$  = is the reduced coefficient matrix

$\underline{b}$  is the column vector of unknown fixed effects.

$\underline{y} = y$  is the reduced column vector of RHMS.

The solution arrived was that

$\underline{b} = C^{-1} \cdot y$  which gave the estimate of least square constants, where,  $C^{-1}$  is the inverse of reduced coefficient matrix.

The least squares constants for absorbed effects were calculated by making the sum of constants for all effects in a group to be zero i.e.

$$\text{i.e., } \sum D_i = \sum S_j = 0$$

Least square means were calculated by adding the estimate of specific effect (constant) to the estimate of general mean  $\mu$  viz.,  $\mu + D_i$  least squares means of  $i^{\text{th}}$  district group.

### 3.9.2.2 ESTIMATION OF STANDARD ERROR OF LEAST SQUARES MEANS

The standard error (SE) of LS means was computed as

$$SE(\mu + G_i) = \sqrt{(C^{11} + C^{ii} + 2C^{li})\sigma^2}$$

Where,  $C^{11}$  = Corresponding diagonal inverse element for the mean

$C^{ii}$  = Corresponding diagonal inverse element for the  $i^{\text{th}}$   
constant in a group (say breeding group)

$C^{li}$  = Inverse element of first row and corresponding column to  
 $i^{\text{th}}$  constant in the said group.

The inverse elements for the absorbed column and row were computed from the dependencies which caused the inverse elements within a group to sum up to be as zero by rows and columns.

Thus,

$$C^{i,p} = -(C^{i,2} + C^{i,3} + \dots + C^{i,p-1})$$

$$C^{p,p} = -(C^{1,p} + C^{2,p} + \dots + C^{p-1,p})$$

Where,

$C^{i,p}$  = the inverse element of  $i^{\text{th}}$  row and column, corresponding  
to  $p^{\text{th}}$  effect in a group.

$C^{p,p}$  = the diagonal inverse element corresponding  
to  $p^{\text{th}}$  effect within a group.

The elements of the row and column corresponding to  $p^{\text{th}}$  effect in a group were made zero by imposing the restriction, then the error variance was estimated as

$$\sigma_e^2 = 1 / f \left[ Y_{ijk1}^2 - R(b_i) \right]$$

where,

$f$  = error degrees of freedom

$R(b_i)$  = reduction due to fitting all constants

$$R(b_i) = \underline{b}^i \cdot \underline{y}$$

Where,  $\underline{b}^i$  = row vector of LS constants estimated for all fixed effects.

$\underline{y}$  = Column vector of sums taken over each group i.e. right hand  
vector before imposing restrictions.

### 3.9.3 COMPUTATION OF SUM OF SQUARES

The sum of squares due to different effects were calculated as

$$SS_b = B^1 Z^{-1} B$$

Where,

$SS_b$  = Sum of squares due to  $b^{\text{th}}$  group

$B$  = Column vector of constant estimates for all effects in a  $b^{\text{th}}$  group

$Z^{-1}$  = Inverse of the segment of the inverse of the coefficient matrix  
corresponding to the row and column of  $b^{\text{th}}$  group of constants

$B^1$  = Transpose of  $B$  (row vector of constant estimates for all effects in  
the  $b^{\text{th}}$  group)

The sum of squares for the particular group was divided by corresponding degrees of freedom to obtain mean sum of squares of that group.

The error mean sum of squares was  $\sigma_e^2$ . The 'F' test was used to detect the significance of different group effects.

#### ANALYSIS OF VARIANCE

Sources of variation	d.f.	SS	MSS	F value
Between sex	$(n_i - 1)$	$SS_i$	$SS_i$	a/c
			----- = a $(n_i - 1)$	
Between district	$(n_j - 1)$	$SS_j$	$SS_j$	b/c
			----- = b $(n_j - 1)$	
Error	$[N - (n_i + n_j) + 1]$	SS	$SS_e$	
			----- = c $[N - (n_i + n_j) + 1]$	
Total	N - 1			

#### 3.9.4 COMPARISON OF MEANS

The least squares means of different factors were subjected to LSD test (Snedecor and Cochran, 1989) where effects were found to be significant at five per cent level ( $P \leq 0.05$ ).

#### 3.9.5 COMPUTATION ONE WAY ANOVA FOR REPRODUCTIVE TRAITS

One way analysis of variance with unequal sub group frequencies was carried out to analyse reproductive traits like age at first lambing and inter lambing period over different locations / districts as per the procedure described by Snedecor and Cochran (1989). The means different factors were subjected to LSD test where effects were found to be significant at five per cent level ( $P \leq 0.05$ ), for this following mathematical model was used.

$$Y_{ij} = \mu + Y_i + e_{ijk}$$

Where,

$Y_{ij}$  = Observation on  $i^{\text{th}}$  individual belonging to  $j^{\text{th}}$  district

$\mu$  = Overall mean

$Y_i$  = Effect of  $i^{\text{th}}$  district of birth

$e_{ijk}$  = Random error associated with  $i^{\text{th}}$  individual and assumed to be normally independently distributed with mean '0' and unit  $\sigma_e^2$ .

### 3.10 ESTIMATION OF GENETIC PARAMETERS

#### 3.10.1 ADJUSTMENT OF RECORDS

For effective genetic analysis, the variation due to non-genetic factors was necessary for adjustment. The data were adjusted for all significant non-genetic factors affecting particular trait under this study.

Additive correction factor (CF) was calculated as follows :

$$\text{Correction factor} = - (D_i + S_j)$$

Where,

$D_i$  and  $S_j$  were the least squares constants for  $i^{\text{th}}$  location / district and  $j^{\text{th}}$  sex is sex effect respectively.

$$\text{i.e. } Y_{ijk} = Y_{ijk} + \text{CF}$$

where,

$Y_{ijk}$  and  $Y_{ijk}$  were corrected and uncorrected records, respectively.

#### 3.10.2 HERITABILITY ESTIMATES

Heritability was estimated for body weights of 3, 6, 9 and 12 months aged sheep. The records adjusted for significant effects of the non-genetic factors were used to estimate heritability and also considering only those rams that had at least



**Fig . 10 Bandur ram with progenies (lambs)**



**Fig . 11 Flock of Bandur sheep**

three lambs in the specific age group, based on the information from the farmers with single breeding ram in the flock regarding the parentage of the sheep and were grouped according to sires for calculation of heritability. Estimation of heritability was carried out using the sire component of variance (Patro *et al.*, 2006).

Genetic correlation were not estimated as the body weights were not paired as they belonged to entirely different group of sheep.

Heritability ( $h^2$ ) was estimated by paternal half-sib analysis method as outlined by Becker (1975). Following mathematical model was used.

$$Y_{ijk} = \mu + S_i + e_{ijk}$$

Where,

$Y_{ijk}$  = adjusted record of  $j^{\text{th}}$  progeny born to  $i^{\text{th}}$  sire.

$\mu$  = Overall mean common to all individuals.

$S_i$  = Random effect of  $i^{\text{th}}$  sire common to all individuals.

$e_{ijk}$  = Random error associated with  $Y_{ijk}$

Errors were assumed to be distributed normally identically and independently with mean zero and unit variance ( $\sigma_e^2$ ).

Assumption :  $\Sigma (S_i) = \Sigma (e_{ijk}) = 0$

$$E (S_i)^2 = \sigma_s^2 \text{ and } E (e_{ijk})^2 = \sigma_e^2$$

#### ANALYSIS OF VARIANCE FOR SIRE VARIANCE

Source of variation	df	MSS	EMSS
Between sires	S-1	$MS_s$	$\sigma_e^2 + K \sigma_s^2$
Between progeny within sire	N-S	$MS_e$	$\sigma_e^2$

Where,

$$\sigma_e^2 = MS_e$$

$$\sigma_e^2 = \frac{MS_e - MS_e}{\bar{K}}$$

$\bar{K}$  = weighted average number of progeny per sire

$$\bar{K} = \frac{1}{(S-1)} \left( N - \frac{\sum n_i^2}{N} \right)$$

S = Number of sires

$\sum n_i^2$  = Number of progeny of  $i^{\text{th}}$  sire

N = Total number of progeny

Where, t = intra class correlation

$$t = \frac{\sigma_{S^2}}{\sigma_{S^2} + \sigma_{e^2}}$$

$$h^2 = 4 t$$

Then,

$$h^2 = \frac{4 \sigma_{S^2}}{\sigma_{S^2} + \sigma_{e^2}}$$

SE ( $h^2$ ) estimated as per Swiger *et al.* (1964)

$$SE(h^2) = 4 \sqrt{\frac{2(N-1)(1-t)^2 [1 + (\bar{K}-1)t]^2}{\bar{K}^2(N-S)(S-1)}}$$

### 3.10.3 Correlation estimates

Correlation between body weights and body measurements were estimated in six month and twelve month sheep in the present study. The data utilized was corrected for effect of districts for estimation of correlations and predictions of body weights and measurements.

Correlation co-efficient was calculated as per the procedure described by Snedecor and Cochran (1989) and the formula was as follows:

$$r_{xy} = \frac{\Sigma xy}{\sqrt{(\Sigma x^2)(\Sigma y^2)}}$$

Where,  $\Sigma XY$  = is the corrected sum of cross products of  $X_i$  trait and  $Y_i$  trait.

$\Sigma X^2$  = is the corrected sum of squares of  $X_i$  trait.

$\Sigma Y^2$  = is the corrected sum of squares of  $Y_i$  trait.

The standard error of correlation was estimated by using the formula.

$$SE(r) = \frac{1-r^2}{\sqrt{n-2}}$$

The significance of the co-efficient of correlation was tested by using 't' test as per the procedure of Snedecor and Cochran (1989).

### 3.10.4 Prediction estimation

To predict the body weights from biometrical measurements, multiple regression method was used on data of six months and twelve months sheep. Also,

simple linear regression was carried out to predict body weight using only chest girth( $x_1$ ).

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3$$

Y = Predicted body weight

a = Intercept

$X_1$  = Heart / chest girth

$X_2$  = Body length

$X_3$  = Height at withers

$b_1$ ,  $b_2$  and,  $b_3$  are the partial regression coefficients of body weight on  $X_1$ ,  $X_2$  and,  $X_3$ , respectively.

The coefficient of determination ( $R^2$ ) was calculated for each equation and significance of partial regression coefficients were tested by 't' test of significance as per Snedecor and Cochran (1989).



# RESULTS

## **IV. RESULTS**

### **4.1 MORPHOLOGICAL FEATURES**

The data was generated on various morphological features in 2625 adult sheep comprising 600 rams and 2025 ewes was grouped sex-wise and pooled. The parameters examined were coat colour, head profile, presence of wattles and beard, tail features, horn features and ear orientation in their variant expression.

The values of the various morphological features in males and females with respective number and as well as pooled are presented in Table 19.

#### **4.1.1 COAT FEATURES**

##### **4.1.1.1 COAT COLOUR**

The coat colour was predominantly white and light brown face in 1974 sheep (485 rams and 1489 ewes) and constituted 75.20 per cent of the total observed sample population, while those with dull white with light brown markings was observed in 609 (103 rams and 506 ewes) sheep constituting 23.20 per cent of the total sample. Dull brown with white patches was noticed in 42 sheep (12 rams and 30 ewes) and constituted 1.6 per cent.

#### **4.1.2 HEAD PROFILE**

##### **4.1.2.1 FORE HEAD**

The forehead was convex in 1646 sheep (62.27%) consisting of 407 rams (67.83%) and 1239 ewes (61.19%), while concave forehead was noticed in 709 (27.71%) sheep comprising 133 rams (22.17%) and 576 ewes (28.44%). The third variant, straight forehead was observed in 270 sheep constituting 10.28 per cent of

**Table 19 : Morphological features of adult Bannur sheep**

Parameters	Variants	Male		Female		Overall	
		Number	%	Number	%	Number	%
<b>I. Coat features</b>	Numbers →	600	%	2025	%	2625	100.00
a. Coat colour	i. White with light brown face	485	80.83	1489	73.53	1974	75.20
	ii. Dull white with brown marks	103	17.16	506	24.99	609	23.20
	iii. Dull brown with white patches	12	2.0	30	1.48	42	1.6
<b>II. Head profile</b>							
a. Forehead	i. Convex	407	67.83	1239	61.19	1646	62.27
	ii. Concave	133	22.17	576	28.44	709	27.71
	iii. Straight	60	10.00	210	10.37	270	10.28
b. Wattles	i. Present	89	14.83	767	37.88	856	32.61
	ii. Absent	511	85.17	1258	62.12	1769	67.39
c. Beard	i. Present	74	12.33	310	15.31	384	14.63
	ii. Absent	526	87.67	1715	84.69	2241	85.37
<b>III. Tail feature</b>							
a. Shape	i. Curved	213	35.50	1332	65.78	1545	58.86
	ii. Straight	387	64.50	693	34.22	1080	41.14
b. Length	i. Short	107	17.83	487	24.05	594	22.63
	ii. Medium	464	77.33	1421	70.17	1885	71.81
	iii. Long	29	4.83	117	5.78	146	5.56
<b>IV. Horn features</b>							
a. Presence	Present	133	22.17	688	33.98	821	31.28
	Absent	467	77.83	1337	66.02	1804	68.72
b. Color of horn	Black	55	41.35	315	45.78	370	53.78
	White	54	40.60	263	38.23	317	4.07
	Brown	24	18.05	110	15.99	134	19.48
c. Shape	Straight	56	42.11	488	60.76	544	66.26
	Curved	77	57.89	200	39.24	277	33.74
<b>V. Ear orientation</b>							
Orientation	Horizontal	50	8.33	355	17.53	405	15.43
	Pendulous	467	77.83	1306	64.49	1773	67.75
	Erect	83	13.83	364	17.98	447	17.02

total sheep, with 10.00 per cent (12) of the rams, and 10.37 per cent (30) ewes showing this trait.

#### **4.1.2.2 TASSLES / WATTLES**

The tassles/wattles were absent in 67.39 per cent (1769) constituting 511 rams (85.17%) and 1258 ewes (64.12%). The wattles were present in 856 sheep (32.61%) comprising 89 (14.83%) rams and 767 ewes (37.88%) of the sampled survey population.

#### **4.1.2.3 BEARD**

The beard was absent in 2241 sheep (85.37%) comprising 526 rams and 1715 ewes in surveyed sheep, while beard was present in 384 sheep (14.63%) constituting 74 rams and 310 ewes of the surveyed sample.

### **4.1.3 TAIL FEATURES**

#### **4.1.3.1 SHAPE OF TAIL**

The shape of tail was categorized as curved and straight. The sheep surveyed comprised of 1545 sheep having curved tail (58.86%) constituting 213 rams (35.50%) and 1332 ewes (65.78%). The remaining 1080 sheep (41.14%) comprising 387 rams (64.5%) and 693 ewes (34.22%) had straight tail.

#### **4.1.3.2 LENGTH OF TAIL**

The length of tail was categorized as short, medium and long. The sheep were mostly medium tailed (71.81%) while 22.63 per cent surveyed sheep were short tailed and 5.56 per cent sheep were long tailed. Out of 2625 surveyed adult sheep 1885 had medium tail (464 rams and 1421 ewes) and 594 had short tail (107 rams and 487 ewes) and also 146 sheep with long tail (29 rams and 117 ewes).

#### **4.1.4 HORN FEATURES**

##### **4.1.4.1 PRESENCE**

Out of 2625 surveyed adult sheep, 1804 sheep were hornless (68.72%) comprising 467 rams (77.83%) and 1337 ewes (62.02%). The percentage of horned sheep were 31.28 per cent (821) and comprised of 133 rams (22.19%) and 688 ewes (33.98%) of the total.

##### **4.1.4.2 COLOUR**

Among the 821 horned sheep, horn colour was black in 370 sheep (53.78%), white in 317 sheep (4.07%) and brown in 134 sheep (19.48%). Correspondingly, the horn colour was black, white and brown in 41.35%, 40.65% and 18.05% in the rams, while the corresponding figures were 45.78, 38.23 and 15.99 per cent, respectively in the horned ewes.

##### **4.1.4.3 SHAPE**

The shape of the horn in the 821 sheep was either straight (66.26%) or curved (33.74%). The corresponding values were 42.11% and 60.76 per cent in rams and 57.89 and 39.24% in the ewes.

#### **4.1.5 EAR ORIENTATION**

The ear orientation expressed in sheep was categorized as horizontal, pendulous and erect. Out of 2625 adult sheep, 1773 exhibited pendulous ears (67.75%) constituting 467 rams (77.83%) and 1306 ewes (64.49%). Erect ears were noticed in 447 sheep (17.02%) comprising 83 rams (13.83%) and 364 ewes (17.98%). While horizontal orientation was observed in 405 sheep (15.43%) constituting 50 rams and 355 ewes.

## **4.2 BODY WEIGHT AND BODY MEASUREMENTS**

### **4.2.1 BODY WEIGHT**

The least square means along with respective standard errors for body weights at various ages are presented in Table 20.

The least square analysis of variance for body weights at various age groups are given in Table 21.

#### **4.2.1.1 THREE MONTHS (0-3)**

Data on 220 lambs were analyzed for estimating body weight. The overall least square means obtained for body weight at three months was  $4.79 \pm 0.09$  kg (Table 20).

#### **4.2.1.2 SIX MONTH (3-6)**

The overall mean six months body weight of 134 lambs was  $11.40 \pm 0.13$  kg (Table 20).

#### **4.2.1.3 NINE MONTH (6-9)**

The overall mean body weight of 574 Bannur sheep at nine months of age was  $15.86 \pm 0.07$  kg (Table 20).

#### **4.2.1.4 TWELVE MONTH (9-12)**

The overall mean obtained for twelve month body weight in was  $26.13 \pm 0.11$  kg (Table 20).

#### **4.2.1.5 ADULT (4-TEETH AND ABOVE 933 sheep)**

A total of 1247 sheep were analyzed and the overall mean body weight was  $28.28 \pm 0.04$  kg (Table 20).

**Table 20 : Sex and district wise least square means for body weights ( kg) at various age groups**

Age group		Classification						
		Sexes			Districts			
		Overall	Males	Females	Mandya (D <sub>1</sub> )	Mysore (D <sub>2</sub> )	Bangalore (D <sub>3</sub> )	Kolar (D <sub>4</sub> )
3 month (≤ 3)	N	220	95	125	31	29	126	34
	$\bar{X}$	4.79	4.84 <sup>a</sup>	4.73 <sup>a</sup>	3.39 <sup>c</sup>	6.20 <sup>a</sup>	4.37 <sup>b</sup>	4.39 <sup>b</sup>
	SE	0.09	0.13	0.11	0.26	0.19	0.11	0.42
6 month (≤ 6)	N	134	62	72	48	52	34	-
	$\bar{X}$	11.40	12.11 <sup>a</sup>	10.69 <sup>b</sup>	13.32 <sup>a</sup>	11.96 <sup>a</sup>	8.92 <sup>b</sup>	-
	SE	0.13	0.03	0.03	0.05	0.02	0.28	-
9 month (≤ 9)	N	574	189	385	247	226	83	18
	$\bar{X}$	15.86	15.91 <sup>a</sup>	15.76 <sup>a</sup>	15.85 <sup>a</sup>	15.98 <sup>a</sup>	15.90 <sup>a</sup>	16.01 <sup>a</sup>
	SE	0.07	0.08	0.24	0.18	0.18	0.19	0.14
12 month (≤ 12)	N	933	650	183	267	165	102	399
	$\bar{X}$	26.13	26.32 <sup>a</sup>	25.95 <sup>b</sup>	25.60 <sup>a</sup>	26.21 <sup>a</sup>	26.12 <sup>a</sup>	25.66 <sup>a</sup>
	SE	0.13	0.12	0.36	0.27	0.26	0.27	0.21
Adults (≥ 12)	N	1247	183	1064	378	484	127	258
	$\bar{X}$	28.28	27.48 <sup>b</sup>	29.08 <sup>a</sup>	28.00 <sup>c</sup>	30.45 <sup>a</sup>	27.00 <sup>d</sup>	28.89 <sup>b</sup>
	SE	0.04	0.50	0.18	0.07	0.07	0.15	0.03

Means (  $\bar{X}$  ) bearing same superscript within a sub group are not significantly different from each other (P≤0.05)

**Table 21 : Mean square from least square analysis of variance for body weights at various age groups**

Age source of variation	3 month ( $\leq 3$ )		6 month ( $\leq 6$ )		9 month ( $\leq 9$ )		12 month ( $\leq 12$ )		Adult ( $\geq 12$ )	
	df	MSS	df	MSS	df	MSS	df	MSS	df	MSS
Sexes	1	5.50 <sup>NS</sup>	1	40.36 <sup>**</sup>	1	2.743 <sup>NS</sup>	1	161.013 <sup>**</sup>	1	1281.14 <sup>**</sup>
Districts	3	5.74 <sup>*</sup>	2	68.86 <sup>**</sup>	3	1.885 <sup>NS</sup>	3	6.808 <sup>NS</sup>	3	733.49 <sup>**</sup>
Residual	215	1.495	130	3.095	569	3.55	928	7.59	1242	2.927

\* P ( $\leq 0.05$ )

\*\* P ( $\leq 0.01$ )

NS – Non-significant

## **4.2.2 BODY MEASUREMENTS**

The least square means, along with respective standard errors at various age groups for body measurements are presented in able 22, 24 and 26, respectively.

The least square analysis of variance for chest girth body length and height at withers at various age groups are given in able 23, 25 and 27, respectively.

### **4.2.2.1 CHEST GIRTH (CG)**

The overall mean CG (cm) of the sheep at different age groups were  $45.21 \pm 1.22$ ,  $56.89 \pm 0.40$ ,  $71.40 \pm 0.25$ ,  $77.65 \pm 0.18$  and  $75.98 \pm 0.16$  cm (Table 22) for 3, 6, 9, 12 months and adult sheep, respectively.

### **4.2.2.2 BODY LENGTH**

The mean BL (cm) of pooled data obtained for five age groups in increasing order were  $41.58 \pm 0.49$ ,  $51.20 \pm 0.77$ ,  $53.18 \pm 0.24$ ,  $61.74 \pm 0.95$  and  $63.64 \pm 0.13$  cm respectively (Table 24) for 3, 6, 9, 12 month and adult sheep in the study.

### **4.2.2.3 HEIGHT AT WITHERS**

The mean HW (cm) for pooled data in the five age groups were  $42.66 \pm 0.54$ ,  $45.9 \pm 0.47$ ,  $48.52 \pm 0.08$ ,  $52.20 \pm 0.11$  and  $53.90 \pm 0.10$  cm (Table 26) in age groups 3, 6, 9, 12 month and adult sheep, respectively, in the study.

## **4.3 EFFECT OF NON-GENETIC FACTORS ON BODY WEIGHTS**

### **4.3.1 EFFECT OF SEX**

#### **4.3.1.1 THREE MONTH ( $\leq 3$ )**

The influence of sex was found to be non-significant ( $P > 0.05$ ) for three months body weight. The mean body weight for three month was  $4.84 \pm 0.13$  kg ram lamb and  $4.73 \pm 0.11$  kg in ewe lamb (Table 20).

**Table 22 : Sex and district wise least square means for chest girth (cm) of different age groups**

Age group		Classification						
		Sexes			Districts			
		Overall	Males	Females	Mandya (D <sub>1</sub> )	Mysore (D <sub>2</sub> )	Bangalore (D <sub>3</sub> )	Kolar (D <sub>4</sub> )
3 month (≤ 3)	N	220	95	125	31	29	126	34
	$\bar{X}$	45.21	43.88 <sup>b</sup>	46.88 <sup>a</sup>	46.32 <sup>a</sup>	49.06 <sup>a</sup>	38.08 <sup>a</sup>	47.16 <sup>a</sup>
	SE	1.22	1.73	1.46	3.25	2.39	1.31	1.67
6 month (≤ 6)	N	134	62	72	48	52	34	-
	$\bar{X}$	56.89	57.65 <sup>a</sup>	56.05 <sup>b</sup>	61.83 <sup>a</sup>	60.52 <sup>a</sup>	48.27 <sup>b</sup>	-
	SE	0.40	0.47	0.15	0.73	0.44	1.10	-
9 month (≤ 9)	N	574	189	385	247	226	83	18
	$\bar{X}$	71.40	76.46 <sup>a</sup>	66.35 <sup>b</sup>	70.35 <sup>b</sup>	67.69 <sup>c</sup>	75.66 <sup>a</sup>	70.89 <sup>b</sup>
	SE	0.25	0.27	0.82	0.38	0.60	0.63	0.48
12 month (≤ 12)	N	933	650	283	267	165	102	399
	$\bar{X}$	77.65	78.64 <sup>a</sup>	76.67 <sup>b</sup>	75.91 <sup>b</sup>	77.88 <sup>a</sup>	78.23 <sup>a</sup>	76.31 <sup>b</sup>
	SE	0.18	0.19	0.58	0.44	0.43	0.45	0.34
Adults (≥ 12)	N	1247	183	1064	378	484	127	258
	$\bar{X}$	75.98	75.08 <sup>b</sup>	76.76 <sup>a</sup>	75.99 <sup>a</sup>	78.88 <sup>a</sup>	76.00 <sup>a</sup>	78.04 <sup>a</sup>
	SE	0.16	1.99	0.72	0.32	0.25	0.59	0.13

Means ( $\bar{X}$ ) bearing same superscript within a sub group are not significantly different from each other ( $P \leq 0.05$ )

**Table 23 : Mean square from least square analysis of variance of chest girth for various age groups**

Age source of variation	3 month ( $\leq 3$ )		6 month ( $\leq 6$ )		9 month ( $\leq 9$ )		12 month ( $\leq 12$ )		Adult ( $\geq 12$ )	
	df	MSS	df	MSS	df	MSS	df	MSS	df	MSS
Sexes	1	937.82*	1	310.76*	1	3930.38**	1	2061.37**	1	4029.5**
Districts	3	65.25 <sup>NS</sup>	2	1586.87**	3	31448.97**	3	252.90**	3	25.76 <sup>NS</sup>
Residual	215	234.218	130	20.04	569	39.23	928	20.29	1247	45.74

\* P ( $\leq 0.05$ )

\*\* P ( $\leq 0.01$ )

NS – Non-significant

**Table 24 : Sex and district wise least square means for body length (cm) of different age groups**

Age group		Classification						
		Sexes			Districts			
		Overall	Males	Females	Mandya (D <sub>1</sub> )	Mysore (D <sub>2</sub> )	Bangalore (D <sub>3</sub> )	Kolar (D <sub>4</sub> )
3 month (≤ 3)	N	220	95	125	31	29	26	34
	$\bar{X}$	41.58	41.88 <sup>a</sup>	41.29 <sup>b</sup>	42.17 <sup>a</sup>	42.98 <sup>a</sup>	40.01 <sup>b</sup>	42.79 <sup>a</sup>
	SE	0.49	0.69	0.59	1.30	0.98	0.52	0.21
6 month (≤ 6)	N	134	62	72	48	52	34	-
	$\bar{X}$	51.20	53.88 <sup>a</sup>	50.03 <sup>b</sup>	55.88 <sup>a</sup>	52.61 <sup>a</sup>	45.14 <sup>a</sup>	-
	SE	0.77	1.10	1.04	1.40	1.11	1.75	-
9 month (≤ 9)	N	574	189	385	247	226	83	18
	$\bar{X}$	53.07	53.78 <sup>a</sup>	52.05 <sup>b</sup>	53.69 <sup>a</sup>	51.54 <sup>a</sup>	55.00 <sup>a</sup>	55.04 <sup>a</sup>
	SE	0.22	0.24	0.72	0.54	0.53	0.55	0.42
12 month (≤ 12)	N	933	650	283	267	165	102	399
	$\bar{X}$	61.74	62.73 <sup>a</sup>	60.76 <sup>b</sup>	61.44 <sup>c</sup>	63.29 <sup>ab</sup>	62.29 <sup>bc</sup>	63.77 <sup>a</sup>
	SE	0.95	0.33	0.98	0.74	0.71	0.75	0.57
Adults (≥ 12)	N	1247	183	1064	378	484	127	258
	$\bar{X}$	63.64	62.81 <sup>b</sup>	64.46 <sup>a</sup>	62.83 <sup>b</sup>	63.65 <sup>a</sup>	64.10 <sup>a</sup>	62.60 <sup>b</sup>
	SE	0.13	1.61	0.58	0.26	0.22	0.47	0.10

Means ( $\bar{X}$ ) bearing same superscript within a sub group are not significantly different from each other ( $P \leq 0.05$ )

**Table 25 : Mean square from least square analysis of variance for body length of different age groups**

Age source of variation	3 month ( $\leq 3$ )		6 month ( $\leq 6$ )		9 month ( $\leq 9$ )		12 month ( $\leq 12$ )		Adult ( $\geq 12$ )	
	df	MSS	df	MSS	df	MSS	df	MSS	df	MSS
Sexes	1	5211.5**	1	351.81*	1	837.83**	1	1931.55**	1	705.06**
Districts	3	1733.50*	2	150.32 <sup>NS</sup>	3	14.49 <sup>NS</sup>	3	211.76**	3	325.55**
Residual	215	37.61	130	74.15	569	30.46	928	56.29	1247	30.01

\* P ( $\leq 0.05$ )

\*\* P ( $\leq 0.01$ )

NS – Non-significant

**Table 26 : Sex and district wise least square means for height at withers (cm) at various age groups**

Age group		Classification						
		Sexes			Districts			
		Overall	Males	Females	Mandya (D <sub>1</sub> )	Mysore (D <sub>2</sub> )	Bangalore (D <sub>3</sub> )	Kolar (D <sub>4</sub> )
3 month (≤ 3)	N	220	95	125	31	29	126	34
	$\bar{X}$	42.66	42.58 <sup>a</sup>	42.74 <sup>a</sup>	46.17 <sup>a</sup>	41.19 <sup>a</sup>	42.43 <sup>a</sup>	44.47 <sup>a</sup>
	SE	0.54	0.87	0.65	0.75	0.94	0.94	0.23
6 month (≤ 6)	N	134	62	72	48	52	34	-
	$\bar{X}$	45.9	46.40 <sup>a</sup>	44.01 <sup>b</sup>	50.86 <sup>a</sup>	48.40 <sup>b</sup>	36.32 <sup>c</sup>	-
	SE	0.47	0.66	0.64	0.86	0.69	1.08	-
9 month (≤ 9)	N	574	189	385	247	226	83	18
	$\bar{X}$	48.52	47.32 <sup>b</sup>	49.72 <sup>a</sup>	50.36 <sup>a</sup>	49.22 <sup>b</sup>	43.99 <sup>d</sup>	46.53 <sup>c</sup>
	SE	0.08	0.99	0.36	0.10	0.14	0.29	0.06
12 month (≤ 12)	N	933	650	283	267	165	102	399
	$\bar{X}$	52.20	52.80 <sup>a</sup>	51.56 <sup>b</sup>	54.50 <sup>a</sup>	48.99 <sup>b</sup>	54.58 <sup>a</sup>	53.67 <sup>a</sup>
	SE	0.11	0.13	0.38	0.29	0.28	0.29	0.22
Adults (≥ 12)	N	1247	183	1064	378	484	127	258
	$\bar{X}$	53.90	53.03 <sup>b</sup>	54.89 <sup>a</sup>	52.39 <sup>d</sup>	54.75 <sup>a</sup>	53.29 <sup>b</sup>	52.50 <sup>c</sup>
	SE	0.10	0.17	0.51	0.39	0.38	0.39	0.30

Means ( $\bar{X}$ ) bearing same superscript within a sub group are not significantly different from each other ( $P \leq 0.05$ )

**Table 27 : Mean square from least square analysis of variance of height at withers for different age groups**

Age source of variation	3 month ( $\leq 3$ )		6 month ( $\leq 6$ )		9 month ( $\leq 9$ )		12 month ( $\leq 12$ )		Adult ( $\geq 12$ )	
	df	MSS	df	MSS	df	MSS	df	MSS	df	MSS
Sexes	1	30.32 <sup>NS</sup>	1	947.49 <sup>**</sup>	1	7229.25 <sup>**</sup>	1	1663.29 <sup>**</sup>	1	6457.81 <sup>**</sup>
Districts	3	45.54 <sup>NS</sup>	2	295.39 <sup>**</sup>	3	22.92 <sup>*</sup>	3	201.05 <sup>**</sup>	3	2430.81 <sup>**</sup>
Residual	215	46.25	130	28.18	569	8.68	928	15.56	1247	11.47

\* P ( $\leq 0.05$ )

\*\* P ( $\leq 0.01$ )

NS – Non-significant

#### **4.3.1.2 SIX MONTHS ( $\leq 6$ )**

The mean six month ram lamb BW was  $12.11 \pm 0.03$  kg and that of ewe lamb was  $10.69 \pm 0.03$  kg respectively (Table 20). The observed difference for six month body weight between the sexes was significant ( $P \leq 0.05$ ).

#### **4.3.1.3 NINE MONTHS ( $\leq 9$ )**

The effect of sex was found to be non-significant ( $P > 0.05$ ) for nine month body weight. The mean nine month BW of rams was  $15.91 \pm 0.08$  kg and that of ewes was  $15.76 \pm 0.24$  kg (Table 20).

#### **4.3.1.4 TWELVE MONTHS ( $\leq 12$ month = 2 teeth)**

The observed mean twelve month BW of rams was  $26.32 \pm 0.12$  kg and in ewes it was  $25.95 \pm 0.36$  kg. The observed differences among twelve months body weight due to sex was significant ( $P \leq 0.05$ ).

#### **4.3.1.5 ADULT (above 12 months)**

The mean adult BW was  $27.48 \pm 0.50$  kg in rams and  $29.08 \pm 0.18$  kg in ewes (Table 20). The observed differences among adult body weights of the two sexes was significant ( $P \leq 0.05$ ). Ewes were significantly heavier than rams (Table 20).

### **4.3.2 EFFECT OF LOCATION OR DISTRICT**

#### **4.3.2.1 THREE MONTHS ( $\leq 3$ )**

The least square analysis of variance indicated significant ( $P \leq 0.05$ ) effect of district for 3 month body weight (Table 20). The mean three months BW for Districts 1, 2, 3 and 4 were  $3.39 \pm 0.26$ ,  $6.20 \pm 0.19$ ,  $4.37 \pm 0.11$  and  $4.39 \pm 0.42$  kg, respectively. Lambs located in District 2 were heavier than other districts, while the means of District 3 and 4 did not differ significantly. The lambs placed in District 1 were weighing lower than other districts and differed significantly ( $P \leq 0.05$ ).

#### **4.3.2.2 SIX MONTHS ( $\leq 6$ )**

The least square analysis of variance indicated (Table 21) highly significant influence of district on six months BW ( $P \leq 0.05$ ).

The mean six months BW in sheep of Districts 1, 2 and 3 were  $13.32 \pm 0.05$ ,  $11.96 \pm 0.02$  and  $8.92 \pm 0.28$  kg respectively. A significantly higher BW was recorded in sheep of District 1 followed by those of District 2. There was significant difference among the mean six months body weight of sheep of different districts ( $P \leq 0.05$ ).

#### **4.3.2.3 NINE MONTHS**

The least square means for nine months BW were  $15.85 \pm 0.18$ ,  $15.98 \pm 0.18$ ,  $15.90 \pm 0.19$  and  $16.01 \pm 0.14$  kg for Districts 1, 2, 3 and 4 respectively (Table 20). There were no significant differences among the body weight means at nine months of the four districts ( $P > 0.05$ ).

#### **4.3.2.4 TWELVE MONTHS**

The mean twelve months BW for Districts 1, 2, 3 and 4 were  $25.60 \pm 0.27$ ,  $26.21 \pm 0.26$ ,  $26.12 \pm 0.27$  and  $25.66 \pm 0.21$  kg. There were no significant differences ( $P > 0.05$ ) among the means of the four districts (Table 20). The least square analysis of variance indicated there was no significant effect of districts on twelve months BW (Table 21).

#### **4.3.2.5 ADULTS**

The least square body weight means for adult sheep were  $28.00 \pm 0.07$ ,  $30.45 \pm 0.07$ ,  $27.00 \pm 0.15$  and  $28.89 \pm 0.03$  kg (Table 20) for Districts 1, 2, 3 and 4, respectively. There was significant difference among the means of different districts ( $P \leq 0.05$ ).

### **4.3.3 EFFECT OF NON-GENETIC FACTORS ON BODY MEASUREMENTS**

#### **4.3.3.1 CHEST GIRTH**

##### **4.3.3.1.1 EFFECT OF SEX OF SHEEP**

The mean CG (cm) for males sheep (ram lambs and rams) of five age groups were  $43.88 \pm 1.73$ ,  $57.65 \pm 0.47$ ,  $76.46 \pm 0.27$ ,  $78.64 \pm 0.19$  and  $75.08 \pm 1.99$  cm, respectively. The corresponding value in the females were  $46.88 \pm 1.46$ ,  $56.05 \pm 0.15$ ,  $66.35 \pm 0.82$ ,  $76.67 \pm 0.58$  and  $76.76 \pm 0.72$  cm respectively.

The effect of sex was found to be significant for ( $P < 0.05$ ) CG of three (ewes had higher CG), six, nine and twelve month and adult sheep. Rams had higher CG than ewes among nine and twelve month sheep (Table 22).

##### **4.3.3.1.2 EFFECT OF DISTRICTS**

The least square means of CG of sheep at three months ranged from  $38.08 \pm 1.37$  in District 3 to  $49.06 \pm 2.39$  in District 2. There was no significant difference among the least square means of CG (cm) for three month lambs born in various districts.

The least square mean CG of six month lambs born in Districts 1, 2 and 3 were  $61.83 \pm 0.73$ ,  $60.52 \pm 0.44$  and  $48.27 \pm 1.10$  cm respectively (Table 22). There were significant differences among the least square means of CG (cm) in six month lambs placed at various districts. Highest CG was observed among lambs belonging to District 1 and did not differ significantly with lambs of District 2 ( $P \leq 0.05$ ) while they differed significantly from District 3.

There was significant difference among the least square means of CG (cm) in nine month lambs placed in various districts ( $P \leq 0.05$ ). The mean CG of nine month of sheep born in Districts 1, 2, 3 and 4 were  $70.35 \pm 0.38$ ,  $67.69 \pm 0.60$ ,  $75.66 \pm 0.63$

and  $70.89 \pm 0.48$  cm, respectively (Table 22). Highest CG was in sheep belonging to District 3. There was no differences in mean CG among sheep of Districts 4 and 1, while the sheep in District 3 and 2 differed significantly from all other districts ( $P \leq 0.05$ ).

The least square means for CG in twelve months sheep placed in Districts 1, 2, 3 and 4 were  $75.91 \pm 0.44$ ,  $77.85 \pm 0.43$ ,  $78.23 \pm 0.45$  and  $76.31 \pm 0.34$  cm, respectively (Table 22). Significant effect of district was noticed on mean CG of twelve month sheep. The highest CG was noticed in sheep of District 3 and differed significantly from District 1 and 3 while did not differ with District 2. There was no significant differences between District 1 and 4 also between District 2 and 3.

The mean values for CG of adult sheep placed in four districts were  $75.99 \pm 0.32$  cm (District 1)  $78.88 \pm 0.28$  (District 2),  $76.08 \pm 0.59$  cm (District 3) and  $78.41 \pm 0.13$  cm (District 4). There were no significant differences between the means ( $P > 0.05$ ).

#### **4.3.3.2 BODY LENGTH (BL)**

##### **4.3.3.2.1 EFFECT OF SEX**

The least square mean values of BL in ram and ewe lambs of three month were  $41.88 \pm 0.69$  and  $41.29 \pm 0.59$  cm respectively (Table 24). The observed difference among BL of different sexes was significant ( $P \leq 0.05$ ).

The least square mean BL of ram lambs at six month was  $53.88 \pm 1.10$  cm and that of ewe lamb was  $50.03 \pm 1.04$  cm (Table 24). Significant difference was observed between the means of ram and ewe lambs of six month age ( $P \leq 0.05$ ).

The BL of nine month rams and ewes were  $53.78 \pm 0.25$  and  $52.05 \pm 0.72$  cm, respectively (Table 24). The differences between the sexes was significant ( $P \leq 0.05$ ).

The average BL of twelve month rams and ewes were  $62.73 \pm 0.33$  and  $60.76 \pm 0.98$  cm, respectively (Table 24). The difference observed between sexes was significant ( $P \leq 0.05$ ).

The mean BL of adult rams and ewes (adult) were  $62.81 \pm 1.61$  and  $64.46 \pm 0.58$  cm, respectively (Table 24). The difference was statistically significant with ewes having higher BL ( $P \leq 0.05$ ).

#### **4.3.3.2.2 EFFECT OF DISTRICT**

The least square mean values for BL of three month sheep placed in Districts 1, 2, 3 and 4 were  $42.17 \pm 1.30$ ,  $42.98 \pm 0.98$ ,  $40.01 \pm 0.52$  and  $42.79 \pm 0.21$  cm, respectively (Table 24). Significant difference was observed between the means of BL among different districts ( $P > 0.05$ ).

The mean BL among six month sheep placed in Districts 1, 2 and 3 were  $55.88 \pm 1.40$ ,  $52.61 \pm 1.11$  and  $45.14 \pm 1.75$  cm respectively (Table 24). The mean BL differences among the districts were non-significant ( $P > 0.05$ ).

The average BL of nine month sheep placed in District 1, 2, 3 and 4 were  $53.69 \pm 0.54$ ,  $51.54 \pm 0.53$ ,  $55.00 \pm 0.55$  and  $55.04 \pm 0.42$  cm, respectively (Table 24), and the differences were not significant ( $P > 0.05$ ).

Significant mean differences were observed among twelve month sheep placed in different districts ( $P \leq 0.05$ ). The least square mean BL among twelve month sheep placed in Districts 1, 2, 3 and 4 were  $61.44 \pm 0.74$ ,  $63.29 \pm 0.71$ ,  $62.29 \pm 0.75$

and  $63.77 \pm 0.57$  cm, respectively (Table 24). The sheep placed in District 1 showed lower BL differing significant from Districts 2 and 4 but not with District 3. The sheep placed in District 4 showed higher BL and differed significantly from Districts 1 and 3, while the means of Districts 4 and 2 did not differ significantly.

The mean BL in adult sheep placed in Districts 1, 2, 3 and 4 were  $62.83 \pm 0.26$ ,  $63.65 \pm 0.22$ ,  $64.10 \pm 0.47$  and  $62.60 \pm 0.10$  cm, respectively (Table 24). Significant mean differences were observed among adult sheep placed in different districts ( $P \leq 0.05$ ). Highest BL observed among sheep reared in District 3, which differed significantly from the values of Districts 1 and 4. Mean BL of District 2 differed significantly from those of Districts 1 and 2 ( $P \geq 0.05$ ). There was no significant difference between mean BL values of Districts 1 and 4, as also between Districts 2 and 3.

#### **4.3.3.2.3 HEIGHT AT WITHERS (HW)**

The effect of sex found was non-significant on HW among three month lambs ( $P \geq 0.05$ ). The mean HW in ram and ewe lamb was  $42.58 \pm 0.87$  and  $42.74 \pm 0.65$  cm, respectively (Table 26).

The mean HW among six month ram and ewe lambs were  $46.40 \pm 0.66$  and  $44.01 \pm 0.64$  cm, respectively (Table 26). The mean difference between the sexes was significant ( $P \leq 0.05$ ).

The least square mean HW at nine month in rams and ewes were  $47.32 \pm 0.99$  and  $49.72 \pm 0.36$  cm respectively (Table 26). The difference observed between sexes was significant ( $P \leq 0.05$ ) with the ewes having higher HW than rams.

The average HW observed among twelve month rams and ewes was  $52.80 \pm 0.13$  and  $51.56 \pm 0.38$  cm, respectively (Table 26) and the difference was significant ( $P \leq 0.05$ ).

The mean values of HW in adult rams and ewes were  $53.03 \pm 0.17$  and  $54.89 \pm 0.51$  cm, respectively (Table 26). The difference between the sexes was significant with ewes having higher HW.

#### **4.3.3.3 EFFECT OF DISTRICTS**

The least square mean three month HW in lambs reared in Districts 1, 2, 3 and 4 were  $46.17 \pm 0.75$ ,  $41.19 \pm 0.94$ ,  $42.43 \pm 0.94$  and  $44.47 \pm 0.23$  cm, respectively (Table 26). The differences in the means were statistically non-significant ( $P > 0.05$ ).

The average HW of six months lambs placed in District 1, 2 and 3 were  $50.86 \pm 0.86$ ,  $48.40 \pm 0.69$  and  $36.32 \pm 1.08$  cm, respectively (Table 26). There were significant differences between the means of different districts. A higher HW was observed in District 1 and least mean value was observed in sheep of District 3.

The least square mean HW of nine month sheep located in Districts 1, 2, 3 and 4 were  $50.36 \pm 0.10$ ,  $49.22 \pm 0.14$ ,  $43.99 \pm 0.29$  and  $46.53 \pm 0.06$  cm, respectively (Table 26). The means among the district differed significantly ( $P \leq 0.05$ ). The HW was highest in District 1 and least was in District 3.

The mean HW among twelve month sheep located in Districts 1, 2, 3 and 4 were  $54.50 \pm 0.29$ ,  $48.99 \pm 0.28$ ,  $54.58 \pm 0.29$  and  $53.67 \pm 0.22$  cm, respectively (Table 26). The means of HW among sheep of the different districts differed significantly ( $P \leq 0.05$ ). The mean HW of District 3 did not differ significantly from

those of Districts 1 and 4, but differed significantly from that of District 2. The mean HW of Districts 1 and 4 differed significantly from that of District 2 ( $P \leq 0.05$ ).

The least square mean HW for adult sheep placed in Districts 1, 2, 3 and 4 were  $52.39 \pm 0.39$ ,  $54.75 \pm 0.38$ ,  $53.29 \pm 0.39$  and  $52.50 \pm 0.30$  cm, respectively (Table 26). The means among the districts for HW were significantly different ( $P \leq 0.05$ ). Highest HW observed among adult sheep of District 2 and lower mean value among sheep of District 1.

#### **4.4 REPRODUCTIVE TRAITS**

The means with standard error are presented in Table 28, while one way analysis of variance for age at first lambing and lambing interval are presented in Table 29.

##### **4.4.1 MEAN VALUES**

###### **4.4.1.1 AGE AT FIRST LAMBING(AFL)**

A total of 1004 records were analyzed. The overall mean obtained for age at first lambing was  $642.14 \pm 2.95$  days (Table 28).

###### **4.4.1.2 LAMBING INTERVAL (LI)**

The overall lambing interval was  $249.66 \pm 0.56$  days and a total number of 868 ewes information was utilized for analyzing (Table 28).

**Table 28 : District wise means along with standard error for age at first lambing and lambing interval (days)**

Districts		Age at first lambing	Lambing interval
Overall	N	1004	868
	$\bar{X}$	642.14	249.66
	SE	2.95	0.56
Mandya	N	390	256
	$\bar{X}$	499.10 <sup>c</sup>	250.10 <sup>abc</sup>
	SE	2.81	1.13
Mysore	N	137	322
	$\bar{X}$	598.5 <sup>b</sup>	248.5 <sup>b</sup>
	SE	4.24	0.78
Bangalore (Rural)	N	296	62
	$\bar{X}$	645.7 <sup>a</sup>	243.3 <sup>d</sup>
	SE	3.95	1.07
Kolar	N	181	228
	$\bar{X}$	458.6 <sup>d</sup>	252.6 <sup>a</sup>
	SE	3.23	1.27

Means ( $\bar{X}$ ) bearing same superscript within a sub group are not significantly different from each other ( $P \leq 0.05$ )

**Table 29 : Mean squares from analysis of variance for age at first lambing and lambing intervals**

Source of variation	Age at first lambing		Lambing interval	
	df	MSS	df	MSS
Between district	3	1851000*	3	1637*
Between sheep within district	1000	3227	864	269

\*  $P (\leq 0.05)$

## **4.4.2 EFFECT OF NON-GENETIC FACTOR**

### **4.4.2.1 EFFECT OF DISTRICTS**

#### **4.4.2.1.1 AGE AT FIRST LAMBING**

The means of AFL for ewes of Districts 1, 2, 3 and 4 were  $499.1 \pm 2.81$ ,  $598.5 \pm 4.24$ ,  $645.7 \pm 3.94$  and  $458.6 \pm 3.23$  days, respectively (Table 28), and the difference observed among means between the districts were significant ( $P \leq 0.05$ ).

#### **4.4.2.1.2 LAMBING INTERVAL**

The average LI for ewes belonging to Districts 1, 2, 3 and 4 were  $250.1 \pm 1.13$ ,  $248.5 \pm 0.77$ ,  $243.3 \pm 1.07$  and  $252.6 \pm 1.26$  days, respectively (Table 28) and means differed significantly ( $P \leq 0.05$ ) from each other between the districts.

## **4.5 HERITABILITY ESTIMATES ( $h^2$ )**

The data adjusted for only significant effects of non-genetic factors were utilized to estimate the heritabilities of body weights by adopting paternal half sib correlation method. The data were screened and selected based on single ram flocks as per the information of farmers with at least three progenies in the same age group

The heritability estimates were obtained only for within twelve months age group. The heritability values and their respective standard errors and  $\bar{K}$  for body weights and analysis of variances are presented in Tables 30 and 31, respectively.

The heritability estimates was  $0.21 \pm 0.09$ ,  $0.82 \pm 0.23$ ,  $0.19 \pm 0.07$  and  $0.72 \pm 0.06$  for three months, six months, , nine months BW and for twelve months, respectively (Table 31).

**Table 30 : Mean squares from analysis of variance for heritability estimates of body weights at different ages**

Source of variation	Three months		Six months		Nine months		Twelve months	
	df	MSS	df	MSS	df	MSS	df	MSS
Between sires	11	1.015	15	4.356	14	65.5	20	7.203
Between progeny within sires	37	0.8238	57	2.009	36	144.2	55	4.02

**Table 31 : Heritability ( $h^2$ ) estimates for body weights at different ages**

Trait	$h^2 \pm SE$	$\bar{K}$
3 months body weight	$0.2159 \pm 0.099$	4.0667
6 months body weight	$0.8180 \pm 0.2262$	4.5443
9 months body weight	$0.1886 \pm 0.0774$	4.2042
12 months body weight	$0.7168 \pm 0.0601$	3.6117

## 4.6 CORRELATIONS

The simple phenotypic correlation coefficients for BW at six months and twelve months with respective body measurements are presented in Table 3

### 4.6.1 CORRELATION BETWEEN BODY WEIGHT AND BODY MEASUREMENTS

The correlations were estimated between body weights and body measurements and among body measurements of six and twelve month sheep and estimates are presented in Table 32.

The correlations of body weights at six months of age with body measurements were positive and highly significant ( $P \leq 0.01$ ). Moderate to high correlations were noted for BW with CG, BL and HW as  $0.82 \pm 0.03$ ,  $0.75 \pm 0.04$  and  $0.61 \pm 0.05$ , respectively (Table 32).

Association between BW and body measurement were positive and highly significant ( $P \leq 0.01$ ). The coefficient of correlation estimates were CG, BL and HW were  $0.76 \pm 0.01$ ,  $0.50 \pm 0.02$  and  $0.23 \pm 0.03$ , respectively (Table 32).

### 4.6.2. CORRELATION BETWEEN BODY MEASUREMENTS

The coefficient of correlation in six months lambs among all the three body measurements were positive and highly significant ( $P \leq 0.01$ ). The correlation of CG with BL and HW were  $0.82 \pm 0.03$  and  $0.58 \pm 0.06$ , respectively, while correlation coefficient for BL with HW was  $0.76 \pm 0.04$  (Table 32).

In yearlings, the coefficient of correlation between body measurements followed similar trend as six months lambs and observed correlation values for CG with BL and HW were  $0.74 \pm 0.02$  and  $0.79 \pm 0.01$ , respectively (Table 32), while the

**Table 32 : Correlation estimates between body weights and body measurements at six and twelve months**

Traits	6 months				12 months			
	BW	CG	BL	HW	BW	CG	BL	HW
BW	-	0.82** ± 0.03	0.75** ± 0.04	0.61** ± 0.05	-	0.76** ± 0.02	0.50** ± 0.02	0.23 ± 0.03
CG	-	-	0.82** ± 0.03	0.58** ± 0.06	-	-	0.74** ± 0.01	0.79** ± 0.01
BL	-	-	-	0.76** ± 0.04	-	-	-	0.50** ± 0.02

\*\* P (≤ 0.01)

correlation between BL and HW was  $0.50 \pm 0.02$ . All the correlation estimates were highly significant ( $P \leq 0.01$ ).

#### **4.7 PREDICTION OF BODY WEIGHTS BASED ON BODY MEASUREMENTS**

Multiple regression models were fitted for predicting body weight at six and twelve months, from respective body measurements using CG, BL and HW as independent variables ( $X_1$ ,  $X_2$  and  $X_3$ ) and body weight (BW) as dependent variable (Y), and linear regression equation was carried out to predict body weight using only chest girth( $x_1$ ). The multiple regression equations and linear regression equation fitted along with  $R^2$  values for the predication of body weights at six and twelve months of sheep are presented in Table 33.

##### **4.7.1 SIX MONTH**

All the three body measurements contributed significantly to the expression of body weights among six month sheep and the  $R^2$  value of the single fitted multiple regression equation was 70.49 per cent. The contribution of BL and HW in combination as single fitted regression equation was significant with  $R^2$  value of 56.94 per cent (Table 33) while the equations fitted in combination of CG with HW or BL was significant with  $R^2$  value of 70.25 and 69.49 per cent, respectively. The linear regression equation carried out to predict body weight using chest girth( $x_1$ ) was significant with  $R^2$  value of 54.02 per cent.

##### **4.7.2 TWELVE MONTH**

The  $R^2$  value of the fitted multiple regression equations for the prediction of BW of twelve month sheep ranged from 32.39 to 60.54 per cent. It was observed that the partial regression coefficient involving all the three variables ( $X_1$ ,  $X_2$ ,  $X_3$ ) was

more efficient with a higher  $R^2$  value of 60.54 per cent (Table 33). The last three regression fitting were exhibiting almost similar  $R^2$  values of 60.53, 58.38 and 60.36 per cent, respectively. The  $R^2$  value of the single fitted linear regression equation involving single variable ( $X_1$ ) was 51.28 per cent.

**Table 33 : Multiple regression equation for predicting six and twelve month body weight in Bandur sheep**

Age	R <sup>2</sup> (%)
<b>Six month</b>	
$Y_6 = 6.120 + 0.1621 *X_1$	54.02
$Y_6 = 5.024 + 0.1232 **X_1 + 0.0689* X_2$	69.49
$Y_6 = 4.710 +0.1394*X_1 + 0.0598*X_3$	70.25
$Y_6 = 4.637 + 0.1914**X_2 +0.027X_3$	56.94
$Y_6 = 4.543 +0.1271*X_1 + 0.0317X_2 + 0.0461*X_3$	70.49
<b>Twelve month</b>	
$Y_{12} = - 9.130 + 0.3851*X_1$	51.28
$Y_{12} = - 6.128 + 0.4304**X_1 - 0.1088*X_2$	58.38
$Y_{12} = -5.337 + 0.4262**X_1 - 0.1235*X_3$	60.36
$Y_{12} = - 6.096 + 0.653X_2 -0.0284X_3$	32.39
$Y_{12} = - 6.2654 +0.4051**X_1 + 0.0697X_2 - 0.1559*X_3$	60.54

\*\* P ( $\leq 0.01$ ), \*P ( $\leq 0.05$ )



# **DISCUSSION**

## V. DISCUSSION

Karnataka possesses several sheep breeds such as Bandur, Hassan and Bellary apart from a large number of nondescript sheep. Of these, Bandur sheep which is also commonly referred to as Bandur or Mandya, is one of the best recognized sheep breed known for its organoleptic studies. Over the years, erosion of the pure animals has taken place due to crossbreeding with rams of exotic breeds as well as due to indiscriminate slaughter of high genetic potential sheep. Hence the present study was undertaken to collect data on the morphological features, body weights and reproductive traits of the sheep in the breeding tract.

### 5.1. MORPHOLOGICAL FEATURES OF SHEEP

#### 5.1.1 COAT COLOUR

The coat colour mainly the wool colour, is the externally observable colour on the body of sheep. It is inherited qualitatively and is characteristic of a breed in a large animal population with variants being observed. The coat colour in Bandur sheep was predominantly white with light brown face and constituted 75.20 per cent of the total surveyed samples, those with dull white coat colour with brown marking constituting 23.20 per cent of the total. The least variant dull brown was reported in 42 sheep (1.60%).

White coat colour has been commonly recognized in a number of sheep breeds such as Balangir (Vij *et al.*, 1997), Garole (Arora, *et al.*, 2005) Hassan (Jain *et al.*, 2005), Rampur Bushair (Dixit *et al.*, 2005), Sonadi (Tailor *et al.*, 2006) and in Gurez and Karnah (Anon., 2013) breeds of sheep.

On the other hand, Kushwaha *et al.* (1997) observed reddish brown to black tan colour in Chokla breed. Raman *et al.* (2003) reported that body colour varied from light to dark red / brown / tan in Madras Red sheep. As per Anon.(2004b) report, the Deccani sheep were predominantly black. Jain *et al.* (2005) observed that sheep of Bellary breed were either completely black (36.6%), black with white spots (22.0%) or black with white spots (14.0%). According to Karunanithi *et al.* (2005) and Anon. (2004a), the body colour variants noted in Mecheri sheep were light brown (42.20%), light brown with white patch on head (20.64%), light brown with white colour legs (25.67%), light brown with white spots (10.09%) and completely white (1.40%).

Coat colour thus appears to be a breed specific character. The presence of varying colour combinations indicates the operation of many alleles, or with several loci acting in combination. Bandur sheep are found to be characterised with white colour on the body with brown patches on the face and shoulders.

## **5.1.2 HEAD PROFILE**

### **5.1.2.1 SHAPE OF FOREHEAD**

The shape of the forehead is a specific character to identify various breeds and is an important morphological trait. The forehead was convex in most (62.27%) of the Bandur sheep studied. Forehead was also noticed to be concave in 27.71 per cent sheep and straight in 10.28 per cent.

Dixit *et al.* (2005) reported convex forehead in Rampur Bushair sheep and Devendran *et al.* (2008) reported convex forehead in Coimbatore breed. The forehead was more commonly convex (68.4%), while slightly convex (23.2%) and straight (8.4%) foreheads were also described in Niligiri sheep also by Anon. (2013). Contrary to above findings, shape of forehead was reported to be flat in Deccani breed

(Anon.2004b). Raman *et al.* (2003) and Anon. (2013) had reported straight (97.2%) and convex (2.8 per cent) forehead in Madras Red sheep.

The shape of the forehead is an important breed specific external trait in cattle and buffaloes unlike in sheep

#### **5.1.2.2 WATTLES**

Wattles were absent in most of the sheep studied (67.39%) with the wattles being absent in 85.17 per cent of the rams in 62.12 per cent of the ewes. Absence of wattles was also reported by Kushwaha *et al.* (1997) in Chokla breed of sheep. As per Anon. (2008), wattles were absent in both sexes of Chotanagpuri, while in Niligiri sheep wattles were absent in 75 per cent of the sheep (Anon., 2008). Karunanithi *et al.* (2005) reported that wattles were present equally in both sexes. In Madras Red sheep also, wattles were present in both sexes (Raman *et al.*, 2003).

#### **5.1.2.3 BEARD**

The beard were absent in most of the sheep surveyed (85.37%). Beard was absent in 87.67 per cent of rams and in 84.69 per cent ewes.

Absence of beard was also reported in other breeds in Chokla breed (Kushwaha *et al.*, 1997), Bellary (Jain *et al.*, 2005) and Hassan (Jain *et al.*, 2006) breeds of sheep. The report of Anon. (2008) indicated absence of beard in Nali and in Sonadi sheep. Absence of beard in both sexes appears a common characteristic of the Indian breeds of sheep

### **5.1.3 TAIL FEATURES**

#### **5.1.3.1 SHAPE OF TAIL**

The tail shape was categorized as curved and straight. In the present study, curved tail was noticed in most of the sheep (58.86%) and followed by straight (41.14%).

In contrary to above report, straight tail was reported by Jain *et al.* (2005) in Bellary breed, Jain *et al.* (2005) in Mandya, Dixit *et al.* (2006) in Rampur Bushair, Jain *et al.* (2006) in Hassan breed and Anon. (2013) in Gurez and Karnah breed of sheep.

In contrary to above report tail was observed to be cylindrical in Chokla sheep (Kushwaha *et al.*, 1997), while it was curved in Chotonagpuri breed tail (Anon, 2008).

#### **5.1.3.2 TAIL LENGTH**

Tail length was categorized as short, medium and long. In the present study, a high percentage of the Bandur sheep in the survey (71.81 per cent) possessed medium length, while short tail was observed in 22.63 per cent and long tail in 5.56 per cent. Similar to this observation, medium sized tails were observed by Kushwaha *et al.* (1997) in Chokla breed, Raman *et al.* (2003) in Madras Red sheep, and Anon.(2013) in Chotanagpuri, in Sonadi, Gurez and Karnaha sheep.

Short tail was observed in Bellary sheep by Jain *et al.* (2005) and Hassan breed by Jain *et al.* (2006), while the report of Anon. (2013) revealed the presence of short tail in Tibetan and Rampur Bushair breed of sheep.

#### **5.1.4 HORN FEATURES**

##### **5.1.4.1 PRESENCE OF HORNS**

Horns in animals are the defensive aids and give better look as compared to polled animals. However, Bandur sheep was characterized largely with the percentage of hornless or polled animals being 68.72 whereas the per cent age of horned sheep was 31.28.

Dass and Hari Prasad (2007) reported absence of horns in both the sexes of Muzafarnagari sheep and Kushwaha *et al.* (1997) reported absence of horns in both the sexes of Chokla sheep. In most other Indian breeds, horns have been observed in Bonpala, Bellary, Hassan and Chotanagapuri (Vij *et al.*, 1997; Jain *et al.*, 2005; Jain *et al.*, 2006; Anon, 2008; Devendran *et al.*, 2008; and Anon, 2013). Presence of horns has been observed only in rams of Coimbatore, Niligiri, Gurez and Karnah breeds (Devendran *et al.*, 2008; and Anon, 2013).

##### **5.1.4.2 COLOUR AND SHAPE OF HORN**

Black was the predominant colour among the horned sheep with 53.78 per cent, while brown was seen in 19.48 per cent and white in 4.07 per cent of the animals. The shape of the horns was mostly straight (66.26%) while curved shape of the horn constituted 33.74 per cent.

Jain *et al.* (2005) reported the presence of thick corrugated curved horns with tips pointed in Bellary rams. Dixit *et al.* (2005) observed long curled white horns in males. Jain *et al.* (2006) reported curved medium size white horns in Hassan rams. Anon. (2013) reported curved (98.27%) horns in males with grey colour (94.15%) in Chotanagpuri breed and also curved white horns in Karnah rams and also reported curved grey colour horns in Madras Red sheep. (Raman *et al.*, 2003)

The presence of shape and colour of the horns are more important physical traits to describe a breed in cattle species. However, it was studied in sheep to find any large population variation.

### **5.1.5 EAR SHAPE AND SIZE**

Shape and size of ears aid in breed identity. The orientation of the ears was pendulous in large proportion (67.75%). Erect ears and horizontal ears were observed in 17.02% and 15.43%, respectively, of the animals studied (Table 19).

The ear shape and ear size are found to be more variable in different breed of sheep. Tailor *et al.* (2006) observed large pendulous ears in Sonadi sheep. Dass and Hariprasad (2007) observed long, broad, flat and drooping ears in Muzzafarnagari sheep. Jain.A and Singh (2008) reported small, stumpy and tubular ears in Balangir breed of sheep. Anon. (2008) reported medium sized ears in Gurez sheep, and horizontal ears (75.17%) and pendulous (16.49%) ears in Chotanagpuri sheep, while ears in Madras Red were pendulous (Raman *et al.*, 2003). The ear orientation is an important external trait with respect to breed identity in cattle, goat and pig breeds.

## **5.2 BODY WEIGHTS**

### **5.2.1 MEAN VALUES**

Body weights of animals in a breed at different stages are important for standardization of breed and are an indicator of their growth potential and also for genetic improvement of weight through selection.

#### **5.2.1.1 COMPARISON OF MEANS**

##### **5.2.1.1.1 THREE MONTHS (0-3)**

The overall least square mean body weight recorded in three month lambs were  $4.79 \pm 0.09$  kg. This observation tallied closely with the reports of Jayashankar

*et al.* (2008) in Mandya ram lambs ( $4.61 \pm 0.26$  kg). However, the body weight at three months reported was lower than findings of Urala (1977), Dikshit (1981), Rajkumar (1981) and Nagaraja *et al.* (1996), whose values ranged from  $8.15 \pm 0.03$  to  $10.98 \pm 2.56$  kg. Much higher mean values for three month sheep ( $16.68 \pm 0.03$  kg) were observed in indigenous sheep of Orissa by Patro *et al.* (2006),  $17.70 \pm 0.5$  kg in Pugal sheep by Dass (2007) and  $15.36 \pm 0.18$  kg in Avikalin by Maroof Ahmad *et al.* (2004). The least overall mean weight at three months reviewed was  $5.10 \pm 0.16$  in Rampur Bushair breed was observed by Dixit *et al.* (2005).

The observed mean three months body weight of Bandur sheep in the present study was lower compared to earlier reports in the same breed. This may be due to the fact that the data was collected from farmers flocks spread over a larger geographical distribution under different feeding, management and environment in contrast to the data from organised sheep farms.

#### **5.2.1.1.2 SIX MONTHS WEIGHT**

The overall least square mean obtained for six months body weight was  $11.40 \pm 0.13$  kg. This was in close agreement with the reports of Urala (1977) in Bandur lambs, Patro *et al.* (2006) in Indigenous sheep of Orissa, and Thiruvankadan *et al.* (2008) in Mecheri sheep. The present findings were much lower than the earlier findings of Dikshit (1981) and Nagaraja *et al.* (1996) in Bannur sheep. Higher estimates were also reported by Poonia (2004) in Munjal, Waghmode *et al.* (2005) in Madgyal and Dass (2007) in Pugal sheep.

In general, variations were observed between the body weights recorded in the present study and the values reported by other workers. This would reflect the varying genetic constitution within breeds and between various breeds, which were exposed to

the different environments, managerial practices adopted at the different farms. Hence, to bring about improvement in body weight of animals within a breed, it is suggested to provide optimal managerial conditions followed by appropriate selection of breeding animals keeping in view the geographical conditions under which the different breeds are raised.

#### **5.2.1.1.3 NINE MONTH WEIGHT**

The overall mean body weight of nine month sheep was  $15.86 \pm 0.07$  kg. This value is in close proximity with those reported by Arora *et al.* (1983) in Chokla, and by Mohanty and Mishra (1992) in Balangir and Ganjam sheep. However, higher values were reported earlier in the same breed by Narayanaswamy *et al.* (1975), Reddy and Rai (1987b) and Nagaraja *et al.* (1996) in Mandya/ B annur sheep. This may be attributed to the fact that the animals might have been reared under farm conditions. Higher values have also been reported by Bhadula and Bhat (1980a) in Muzzafarnagari, Mandal *et al.* (2003) in Muzzafarnagari and Waghmode *et al.* (2008) in Madgyal sheep.

Lower estimates have also been reported by Arora and Acharya (1976) in Mandya sheep, Singh and Singh (1984) in Coimbatore and Thiruvankadan *et al.* (2008) in Mecheri sheep.

The variation observed can be effectively capitalized through appropriate breeding, selection and nutrition for obtaining higher body weight.

#### **5.2.1.1.4 TWELVE MONTH WEIGHT**

Yearling weight in sheep is important because it is considered as marketing weight in most of the meat breeds.

The mean yearling weight computed was  $26.13 \pm 0.11$  kg. This is in close proximity with the reports of Sharma *et al.* (2003b) and Sushil Kumar *et al.* (2003) in Malpura and Maroof Ahmad *et al.* (2004) in Avikalin sheep. However, higher values were reported by Nagaraja *et al.* (1996) and Siddalinga Murthy (2001) in Bannur/Bandur, Arora *et al.* (2005) in Jaisalmeri and Dass (2007) in Pugal sheep. While lower estimates were observed by Urala (1977) and Raj Kumar (1981) in Bannur, Patro *et al.* (2006) in Indigenous, Raman *et al.* (2003) in Madras Red and Kandasamy *et al.* (2006) in Coimbatore sheep.

The differences in mean values of various breeds reported by different investigators indicate difference in genetic constitutions among breeds and also in environmental conditions adopted by various farmers. Hence, optimal managerial condition followed by appropriate recording of data and selection of individuals within a breed for improvement in the body weight can be achieved.

#### **5.2.1.1.5 ADULT WEIGHT**

The least square mean calculated for adult body weight was  $28.28 \pm 0.04$  kg in the present study. This value is in close proximity with the reports of Nagaraja *et al.* (1996) in Bannur and Siddalinga Murthy (2001) in Bandur sheep. The present mean value was higher than those reported by Dayananda (1998) in Tumkur strain and Govindaiah *et al.* (2006) in Mandya sheep, while much higher values were reported by Dass and Hari Prasad (2007) in Muzzafarnagari, Arora *et al.* (2007) in Jaisalmeri and Dass (2006) in Pugal sheep.

The adult body weight reflects the individual animal's potential to gain body weight in fluctuating environmental conditions. Hence, appropriate environment,

selection and breeding plans within a group for obtaining higher body weights are essential.

## **5.2.2 BODY MEASUREMENTS**

Recording of body measurements is the first and foremost step in the phenotypic characterization of livestock.

### **5.2.2.1 CHEST GIRTH (CG)**

#### **5.2.2.1.1 COMPARISON OF MEANS**

The overall least square mean CG among three month lambs was  $45.21 \pm 1.22$  cm. The present estimate was closer with the mean values reported by Mishra *et al.* (2006) in Garole and Jayashankar *et al.* (2008) in Mandya sheep. The present mean value was lower than the values reported by Nagaraja *et al.* (1996) in Bannur, Kushwaha *et al.* (1997) in Chokla and Arora *et al.* (2007) in Jaisalmeri sheep. However, it was higher than the values reported by Kandasamy *et al.* (2006) in Coimbatore sheep.

The overall mean value estimated for six month CG was  $56.89 \pm 0.40$  cm. This value is close to the value reported by Govindaiah *et al.* (2006) in Mandya sheep, however, much higher values were reported by Bhadula *et al.* (1979) in Muzzafarnagari, Nagaraja *et al.* (1996) in Bannur and Poonia *et al.* (2004) in Munjal sheep. While lower values were reported by Mishra *et al.* (2004) in Ganjam sheep.

The estimated least square mean of CG for nine month sheep was  $71.40 \pm 0.25$  cm. The lower values were reported by Nagaraja *et al.* (1996) in Bannur, Mishra *et al.* (2004) in Ganjam and Kandasamy *et al.* (2006) in Coimbatore sheep, while much higher mean values were reported by Dass and Hariprasad (2007) in Muzzafarnagari sheep.

The mean CG for twelve month sheep was  $77.65 \pm 0.18$  cm. Much higher value was reported by Arora *et al.* (1975c) in Nali sheep, while lower values were reported by Nagaraja *et al.* (1996) in Bannur, Narasimham (2002) in Nellore and Deccani, Mishra *et al.* (2004) in Ganjam and Govindaiah *et al.* (2006) in Mandya sheep.

The overall least square mean CG for adult sheep estimated was  $75.98 \pm 0.16$  cm. The observed value is in close proximity to value reported by Narasimham (2002) in Deccani and Govindaiah *et al.* (2006) in Mandya sheep. Higher values in contrast to present value were reported by Mishra *et al.* (2004) in Garole, Dinesh Kumar *et al.* (2006) in Muzzafarnagari and Arora *et al.* (2007) in Jaisalmeri sheep. While much lower mean values were also reported by Kushwaha *et al.* (1997) in Chokla, Siddalinga Murthy (2001) in Bandur and Sreenivasu *et al.* (2003) in Deccani sheep.

#### **5.2.2.2 BODY LENGTH (BL)**

The overall least square mean BL for three month lamb was  $41.58 \pm 0.49$  cm. The present findings is in close proximity with the observed values of Jayashankar *et al.* (2008) in Mandya, Mishra *et al.* (2004) in Ganjam, Nagaraja *et al.* (1996) reported higher value in Bannur, Kushwaha *et al.* (1997) in Chokla and Arora *et al.* (2007) in Jaisalmeri sheep. However, lower values in comparison to the present value were also noticed by Singh and Singh (1974) in Bikaneri, Mishra *et al.* (2004) in Ganjam, Mishra *et al.* (2006) in Garole and Kandasamy *et al.* (2006) in Coimbatore sheep.

The overall mean BL estimated for six month was  $51.20 \pm 0.77$  cm. This value is in close agreement with the findings of Dixit *et al.* (2005) in Rampur Bushair and Govindaiah *et al.* (2006) in Mandya sheep. The present estimate was much higher than the mean BL noted by Mishra *et al.* (2006) in Garole sheep. The present estimate

was much lower than the values observed by Arora *et al.* (1975b) in Malpura, Bhadula *et al.* (1979) in Muzzafarnagari, Nagaraja *et al.* (1996) in Bannur, Mishra *et al.* (2004) in Ganjam and Poonia *et al.* (2004) in Munjal sheep.

The overall mean nine month BL was  $53.18 \pm 0.24$  cm in the present study which was closer with the values reported by Nagaraja *et al.* (1996) in Bannur sheep, Jagatheesan *et al.* (2003) in Mecheri sheep and is lower than the reports of Kandasamy *et al.* (2006) in Coimbatore, Anon. (2004a) in Mecheri and Dass and Hariprasad (2007) in Muzzafarnagari sheep.

The overall mean BL of twelve month sheep was  $61.74 \pm 0.95$  cm. The value was in close conformity with those reported by Arora *et al.* (1975c) in Chokla, Narasimham (2002) in Deccani and Karunanithi *et al.* (2005) in Mecheri sheep. However, higher values were reported by Wadyal and Balaine (1971) in Nali, Arora *et al.* (1975a) in Malpura, Nagaraja *et al.* (1996) in Bannur and Narasimham (2002) in Nellore sheep.

The overall least square mean BL of adult sheep in the present study was  $63.64 \pm 0.13$  cm and the value was closer to the reports of Arora *et al.* (1975a) in Malpura, Govindaiah *et al.* (2006) in Mandya and Dass (2007) in Pugal sheep. However, much higher values were reported by Narasimham (2002) in Deccani and Nellore, Dinesh Kumar *et al.* (2006) in Muzzafarnagari and Arora *et al.* (2007) in Jaisalmeri sheep. While Siddalinga Murthy (2001) reported lower mean BL in Bandur sheep.

### **5.2.2.3 HEIGHT AT WITHERS**

The overall least square mean HW among three month lambs was  $42.66 \pm 0.54$  cm and this is closer to the mean reported by Nagaraja *et al.* (1996) in Bannur

sheep. However, much higher values ( $62.4 \pm 0.36$ ) were reported by Kushwaha *et al.* (1997) in Chokla, Arora *et al.* (2007) in Jaisalmeri, Mandal *et al.* (2007), Dass and Hariprasad ( $57.49 \pm 0.87$ ) in Muzzafarnagari sheep. In contrast to present study, lower values were reported by Dixit *et al.* (2005) in Rampur Bushair, Kandasamy *et al.* (2006) in Coimbatore and Mishra *et al.* (2006) in Garole sheep.

The estimated overall mean value for HW for six month sheep was  $45.9 \pm 0.47$  cm. The estimate was in close proximity with the reports of Govindaiah *et al.* (2006) in Mandya sheep, while much higher value were reported by Arora *et al.* (1975a) in Chokla and Malpura sheep, Nagaraja *et al.* (1996) in Bannur, Mishra *et al.* (2004) in Ganjam and Poonia *et al.* (2004) in Munjal sheep, Mishra *et al.* (2006) reported lower values of HW than the present estimate in Garole sheep.

The overall least square mean for the HW in nine month sheep was  $48.52 \pm 0.08$  cm. Much higher value were reported by Nagaraja *et al.* (1996) in Bannur, Kandaswamy *et al.* (2006) in Coimbatore, Kushwaha *et al.* (1997) in Chokla, Jagatheesan *et al.* (2003) in Mecheri, Dass and Hariprasad (2007) in Muzzafarnagari and Tailor and Yadav (2011) in Sonadi sheep.

The overall mean value for HW in twelve month sheep was  $52.20 \pm 0.11$  cm. This value was in close conformity with the reports of Govindaiah, *et al.* (2006) in Mandya sheep. However, much higher values were observed by Arora *et al.* (1975c) in Chokla breed, Nagaraja *et al.* (1996) in Bannur, Narasimham (2002) in Deccani and Nellore and Mandal *et al.* (2007) in Muzzafarnagari sheep, while lower values for HW was reported by Mishra *et al.* (2006) in Garole sheep.

The overall least square mean for HW in adult sheep computed was  $53.90 \pm 0.10$  cm. This value was in agreement with the report of Siddalinga Murthy (2001) in

Bandur sheep and slightly higher than the value reported by Govindaiah *et al.* (2006) in Mandya sheep. Much higher estimates were reported by Dinesh Kumar *et al.* (2006) and Dass and Hariprasad (2007) in Muzzafarnagari sheep.

In general, the variation observed in body measurements recorded in the present study may be attributed to difference in the genetic makeup of the animals and their geographical distribution apart from various non-genetic factors.

### **5.3 EFFECT OF NON-GENETIC FACTORS ON BODY WEIGHTS**

#### **5.3.1 SEX OF SHEEP**

##### **5.3.1.1 THREE MONTHS WEIGHT**

The sex of sheep did not influence the three month weight significantly. The least square mean for ram lamb was  $4.84 \pm 0.13$  kg and in ewe lambs was  $4.73 \pm 0.11$  kg. Higher values were reported by Dikshit (1981) in Bannur sheep. The present finding is in close proximity to the reports of Jayashankar *et al.* (2008) in Mandya sheep, Mehta *et al.* (2003) and Nehra and Singh (2006) who reported non-significant effect of sex of sheep on three month weight in different breeds of sheep.

##### **5.3.1.2 SIX MONTHS WEIGHT**

The sex of sheep significantly influenced six month weight. The mean of ram lambs was higher ( $12.11 \pm 0.03$  kg) than that of ewe lambs ( $10.69 \pm 0.03$  kg). Similar findings were reported by Dixit *et al.* (2001), Dinesh Kumar *et al.* (2003), Mandal *et al.* (2003), Dass (2006) and Waghmode *et al.* (2008) in different breeds of sheep. However, non-significant effect of sex of lamb was reported by Pattanayak *et al.* (2003) in Ganjam breed and Patro *et al.* (2006) in Indigenous sheep ( $10.56 \pm 0.04$  and  $10.79 \pm 0.03$  kg).

### 5.3.1.3 NINE MONTHS WEIGHT

The present study indicated that sex of sheep did not influence the nine month weight. The mean nine month weight was  $15.91 \pm 0.08$  kg and  $15.76 \pm 0.24$  kg in rams and ewes, respectively. Narayanaswamy *et al.* (1975) and Arora *et al.* (1983) noticed that sex had no influence on nine month weight in different breed of sheep. The nine month weight in rams and ewes reported in the present study were closer to the reports of Jagatheesan *et al.* (2003) in rams and ewes of Mecheri breed.

### 5.3.1.4 TWELVE MONTHS WEIGHT

The sex of sheep significantly influenced the twelve month weight in sheep. Twelve month mean weight in rams was  $26.32 \pm 0.12$  kg and that of ewes was  $25.95 \pm 0.36$  kg which was in close proximity with the findings of Maroof Ahmad *et al.* (2004) in Avikalin sheep. Significant influence of sex were also reported by Dixit *et al.* (2001), Mandal *et al.* (2003), Dass (2006), Patro *et al.* (2006) and Waghmode *et al.* (2008) in various breeds of sheep.

### 5.3.1.5 ADULT WEIGHT

The adult weight was significantly influenced by sex of sheep. The ewes were heavier than ( $29.08 \pm 0.18$  kg) rams ( $27.48 \pm 0.50$  kg). The body weights reported in rams and ewes was closer to the observation of Patro *et al.* (2006) in Indigenous and Govindaiah *et al.* (2006) in Mandya sheep. In contrary to the present finding males were heavier than females in most of the earlier findings by Dayananda (1998) in Tumkur strain and Siddalinga Murthy (2001) in Bandur sheep. However non-significant differences due to sex were reported by Singh and Singh (1974) in Bikaneri sheep. Acharya (1982) reported lower adult body weight of males and females as 27.78 and 29.94 kg respectively in Jaisalmeri sheep.

Growth is generally defined as the increase in size or body weight at a given age and is one of the important selection criteria for improvement of meat purpose animals such as sheep. Among adult sheep, ewes were heavier than rams and the possible reason may be the availability of data on more number of ewes (1064) than rams (183). Secondly female ewes were kept in the flock for more number of productive years, so they will be more aged and matured than the rams, while rams are replaced periodically by the farmers at younger age to avoid inbreeding.

### **5.3.2 PLACE / DISTRICT OF SHEEP**

#### **5.3.2.1 THREE MONTHS WEIGHT**

The district of sheep influenced significantly the three month weight. The lambs of District-2 were heavier than sheep of Districts 1, 3 and 4. Arora *et al.* (2007) also reported significant effect of place/location of sheep on three months weight as sheep in Jaisalmer were heavier than Jodhpur and Barmer districts of Rajasthan. Balasubramanyam and Kumaraswamy (2011) reported significant difference in three month weight between four different centres of Kanchipuram district for Madras Red sheep and Tailor and Yadav (2011) also reported similar findings in Sonadi lambs of Rajasthan. The lambs of Chittorgarh were heavier than other districts. Patro *et al.* (2006) reported non-significant effect of area on three month weight of Indigenous sheep.

#### **5.3.2.2 SIX MONTHS WEIGHT**

The place/district significantly affected the six month weight in sheep. The lambs born in Mandya(D<sub>1</sub>) were heavier than those of other districts ( $13.32 \pm 0.05$  kg) followed by those in Mysore (D<sub>2</sub>) ( $11.96 \pm 0.02$  kg). The findings corroborates with those reported by Boujenane and Kerfal (1990) in D'Man lambs, Arora *et al.* (2007)

in Jaisalmeri lambs, Balasubramanyam and Kumaraswamy (2011) in Madras Red and Tailor and Yadav (2011) in Sonadi sheep (Chittorgarh).

#### **5.3.2.3 NINE MONTHS WEIGHT**

The nine month weight was not significantly influenced by district of sheep. Similar findings were reported by Patro *et al.* (2006) in Indigenous sheep of Orissa. While Arora *et al.* (2007), Balasubramanyam and Kumaraswamy (2011) and Tailor and Yadav (2011) noticed significant differences in nine month weight of sheep belonging to different districts.

#### **5.3.2.4 TWELVE MONTHS WEIGHT**

The district of sheep had no significant effect on twelve month weight in sheep. In contrast, Sreenivasu *et al.* (2003) in Deccani, Arora *et al.* (2007) in Jaisalmeri sheep, Balasubramanyam and Kumaraswamy (2011) in Madras Red and Tailor and Yadav (2011) in Sonadi sheep observed significant influence of place of sheep on twelve month body weight.

#### **5.3.2.5 ADULT BODY WEIGHT**

The adult sheep weight was significantly influenced by district of sheep. Sheep belonging to District 2 were heavier ( $30.45 \pm 0.07$  kg) followed by District 3, D<sub>1</sub> and D<sub>4</sub> ( $28.89 \pm 0.03$ ,  $28.00 \pm 0.09$  and  $27.00 \pm 0.15$  kg).

Sreenivasu *et al.* (2003) reported significant differences of Deccani sheep, with sheep of Koilkan and Mahabubnagar Mandals having higher body weights than the sheep of other six Mandals. Similarly, Arora *et al.* (2007) and Tailor and Yadav (2011) noticed significant differences in body weights of adults between the districts of Rajasthan in Jaisalmeri and Sonadi sheep respectively.

The present study indicated that the district-wise variation in body weights of different age group may be due to differences in micro and macro environmental conditions, feeding and managerial practices.

### **5.3.3 EFFECT OF NON-GENETIC FACTORS ON BODY MEASUREMENTS**

#### **5.3.3.1 SEX OF SHEEP**

##### **5.3.3.1.1 CHEST GIRTH (CG)**

The sex of sheep had no effect on CG of three month ram and ewe lamb. This was in agreement with the reports of Mishra *et al.* (2006) in Garole and Jayashankar *et al.* (2008) in Mandya sheep. However in contrary to the present findings Mishra *et al.* (2004) in Ganjam, Patro *et al.* (2006) in Indigenous and Mandal *et al.* (2007) in Muzzafarnagari sheep reported significant influence of sex on CG of three month lambs.

The CG of six month old ram and ewe lambs was  $57.65 \pm 0.47$  and  $56.05 \pm 0.15$  cm, respectively. Sex of sheep had influence on six month CG. Similar findings were reported by Mishra *et al.* (2004) in Ganjam sheep and Mandal *et al.* (2007) in Muzzafarnagari sheep, while the mean values observed was closer to the findings of Govindaiah *et al.* (2006).

The CG at nine month rams was  $76.46 \pm 0.27$  and that of ewes was  $66.35 \pm 0.82$  cm. The sex of sheep had significant influence on CG of nine month sheep. The present mean estimates were higher than those reported by Nagaraja *et al.* (1996) in Bannur and Kandasamy *et al.* (2006) in Coimbatore sheep. Significant differences were also observed by Arora *et al.* (2007) and Mandal *et al.* (2007) in different breeds of sheep.

The CG of twelve month ram and ewes was  $78.64 \pm 0.19$  and  $76.67 \pm 0.58$  cm, respectively. This was closer to the findings of Mandal *et al.* (2007) in Muzzafarnagari sheep, while it was higher than the observations of Nagaraja *et al.* (1996) in Bannur and Narasimham (2002) in Deccani sheep. In the present study significant influence of sex of sheep on twelve month CG was noted and which is in corroboration of the findings of Siddalinga Murthy (2001) in Bandur sheep, Arora *et al.* (2007) in Jaisalmeri and Dass and Hariprasad (2007) in Muzzafarnagari sheep.

Among adult rams and ewes, the mean CG estimated was  $75.08 \pm 1.99$  and  $76.76 \pm 0.72$  cm respectively and was subjected to any influence of sex. The present findings, was in agreement with significant effect of sex as noted by Arora *et al.* (2007), Dass (2007) and Dass and Hariprasad (2007) in various breeds of sheep. However, the mean values were closer to the observation of Govindaiah *et al.* (2006) in Mandya sheep.

#### **5.3.3.1.2 BODY LENGTH (BL)**

The least square mean BL of three month male and female lambs was  $41.88 \pm 0.69$  and  $41.29 \pm 0.59$  cm, respectively, and significant difference between the mean of male and female lambs was noted. The present mean values were closer to the findings of Mishra *et al.* (2004) in Ganjam lambs ( $42.27 \pm 0.13$  and  $42.12 \pm 0.20$  cm). Significant differences in mean BL of male and female lambs were also reported by Patro *et al.* (2006) in Indigenous, and by Dass and Hariprasad (2007) and Mandal *et al.* (2007) in Muzzafarnagari sheep.

There was significant effect of sex on BL of six month male and female sheep. The mean estimates for male and females were  $53.88 \pm 1.10$  and  $50.03 \pm 1.04$  cm respectively. The present means were closer to the reports of Govindaiah *et al.* (2006)

in Mandya sheep, while higher values than the present observation were reported by Nagaraja *et al.* (1996) in Bannur and Poonia *et al.* (2004) in Munjal sheep. Mishra *et al.* (2006) and Mandal *et al.* (2007) reported significant influence of sex of lamb on BL in various breeds. While Arora *et al.* (2007) reported non-significant effect of sex of lamb on BL in Jaisalmeri sheep which was in agreement with the present findings.

The least square mean BL in nine month males and females was  $53.78 \pm 0.25$  and  $52.05 \pm 0.72$  cm respectively and the differences between the sexes were significant. The present estimate is close to the findings of Jagatheesan *et al.* (2003) in Mecheri sheep, while it was lower than the observations of Nagaraja *et al.* (1996) in Bannur sheep. Similiar to present findings Dass and Hariprasad (2007) and Mandal *et al.* (2007) observed significant differences in BL of ram and ewes in Muzzafarnagari sheep. Mishra *et al.* (2006) reported non-significant effect of sex of lamb on BL of nine month Ganjam sheep

Sex of lamb significantly influenced the BL of twelve month sheep and the mean estimates for ram and ewes was  $62.73 \pm 0.33$  and  $60.76 \pm 0.98$  cm, respectively. This is in agreement with the findings of Siddalinga Murthy (2001) in Bandur sheep, Narasimham (2002) in Deccani and Nellore sheep and Mandal *et al.* (2007) in Muzzafarnagari sheep.

In adult rams and ewes, mean BL differed significantly and the mean values were  $62.81 \pm 1.61$  and  $64.46 \pm 0.58$  cm respectively. Significant differences between the sexes was also noted by Arora *et al.* (2007), Dass (2007) and Dass and Hariprasad (2007) in different breeds of sheep. However, the BL of ewes were higher than rams in the present study.

### 5.3.3.1.3 HEIGHT AT WITHERS (HW)

The effect of sex on HW among three month lambs was found to be non-significant. The present findings were in agreement with the observation of Mishra *et al.* (2006) in Garole lambs, while significant effect of sex was reported by Dass and Hariprasad (2007), Mandal *et al.* (2007) in Muzzafarnagari lambs.

The mean HW among six month ram and ewe lambs was  $46.40 \pm 0.66$  and  $44.01 \pm 0.64$  cm respectively. The mean difference between the sexes was significant. This corroborates with reports of Mandal *et al.* (2007), and Dass and Hariprasad (2007) reported significant differences in HW between sexes in Muzzafarnagari lambs. In contrary to the present findings, non-significant of sex was reported by Arora *et al.* (2007) in Jaisalmeri lambs

Among nine month rams and ewes significant differences between sexes in HW was observed. The mean estimate of HW in males was  $47.32 \pm 0.99$  cm and in ewes was  $49.72 \pm 0.36$  cm. The present estimate was lower than the values reported by Nagaraja *et al.* (1996) in Bannur, Kandasamy *et al.* (2006) in Coimbatore and Dass and Hariprasad (2007) in Muzzafarnagari sheep. Significant influence of sex of sheep on HW has also been reported by Mandal *et al.* (2007) and Arora *et al.* (2007) in different breeds of sheep.

In the present study, HW of twelve month sheep was significantly affected by sex of sheep and this is in agreement with the findings of Narasimham (2002) in Deccani, Arora *et al.* (2007) in Jaisalmeri sheep and Dass (2007) in Pugal sheep.

The HW among adult sheep was significantly different between rams and ewes, where ewes had higher HW than rams ( $53.03 \pm 0.17$  and  $54.89 \pm 0.51$  cm). Similar significant differences between sexes where rams had higher HW were

reported by Narasimham (2002), Arora *et al.* (2007) and Dass and Hariprasad (2007) in different breeds of sheep.

In the present study among adult sheep, ewes were heavier than rams. Ewes were kept in the flock for more number of years, so they will be more aged and matured than the rams, while rams are replaced periodically by the farmers at younger age, which might be the reason to cause present variation in body measurements.

### **5.3.3.2 EFFECT OF LOCATION / DISTRICT**

#### **5.3.3.2.1 CHEST GIRTH**

There was no significant difference among the least square means of CG for three month lambs placed in various districts. Contrary to present findings, significant differences between districts were observed by Arora *et al.* (2007) in Jaisalmeri and Tailor and Yadav (2011) in Sonadi sheep.

The CG of six month sheep was significantly affected by district. A higher CG was observed among lambs of District-1 and lower CG was observed in District-3, which differed significantly from the other two districts. Similar effects were noted by Patro *et al.* (2006), Arora *et al.* (2007) and Tailor and Yadav (2011) in different breeds of sheep.

The effect of place / district was significant on CG among nine month sheep and highest value was observed among sheep of District-3, followed by Districts 4 and 1. Boujenane and Kerfal (1990) in D'Man sheep of Morocco and Tailor and Yadav (2011) in Sonadi sheep observed similar effects in nine month sheep.

The twelve month CG was significantly affected by location and the higher CG was observed among sheep of Districts 3 and 2 which differed significantly from

those of Districts 1 and 4. These findings are in agreement with earlier reports of Sreenivasu *et al.* (2003), Arora *et al.* (2007) and Tailor and Yadav (2011) in different breeds of sheep.

The district/location did not exert significant influence on CG of adult sheep. While in contrary to present findings, Sreenivasu *et al.* (2003), Arora *et al.* (2007) and Tailor and Yadav (2011) observed significant influence of district / Mandal on CG of adult sheep in different breeds.

#### **5.3.3.2.2 BODY LENGTH (BL)**

The three month BL was significantly affected by district of lamb. In agreement to present findings, significant influence of district of sheep was observed by Arora *et al.* (2007) and Tailor and Yadav (2011) in different breeds of sheep.

The mean differences between six months BL among districts was non-significant. This finding is in conformity with the reports of Patro *et al.* (2006) in Indigenous and Arora *et al.* (2007) in Jaisalmeri lambs. While significant influence of district of lambs on BL was reported by Tailor and Yadav (2011) in Sonadi lambs.

District / place were not significantly influencing the mean BL of nine month sheep. However, reports by Boujenane and Kerfal (1990) in D'Man sheep of Morocco and Tailor and Yadav (2011) in Sonadi sheep indicated significant effect of place of sheep on BL of nine month sheep.

The twelve month BL was significantly affected by district of sheep. The highest BL was observed among sheep of District 4 and 2 followed by District-3 and District-1. This finding was in agreement with the reports of Sreenivasu *et al.* (2003), Arora *et al.* (2007) and Tailor and Yadav (2011) in different breeds of sheep.

The mean BL of adult sheep was significantly influenced by district of sheep. The higher BL was observed among sheep of Districts 3 and 2 followed by means of District 1 and 4. This observation is in conformity with the findings of Sreenivasu *et al.* (2003), Patro *et al.* (2006), Arora *et al.* (2007) and Tailor and Yadav (2011) in different breeds of sheep.

#### **5.3.3.2.3 HEIGHT AT WITHERS**

There was no significant effect of district of sheep on HW in three month. However, significant effect of location of sheep were reported by Arora *et al.* (2007) and Tailor and Yadav (2011) in Jaisalmeri and Sonadi sheep, respectively.

The six month mean HW was significantly influenced by district of sheep. Higher mean HWs were observed among sheep of District 1 and lower in District 3. Similar effects were noted by Patro *et al.* (2006) in Indigenous sheep and Tailor and Yadav (2011) in Sonadi sheep (Chittorghar district).

The mean HW of nine month lambs differed significantly, a higher value being observed among sheep of District 1 followed by those of District 2 and lowest HW was among sheep of District 3. Similar effects of location on nine month body weight observed by Patro *et al.* (2006) and Tailor and Yadav (2011) in different breeds of sheep.

Higher least square mean of HW among twelve month sheep was noticed in District 3 and lowest among sheep of District 2. The mean differences between the districts were significant. This corroborates with the reports of Sreenivasu *et al.* (2003), Arora *et al.* (2007) and Tailor and Yadav (2011) in different breeds of sheep.

The location/district had significant effect on HW of adult sheep. The sheep in District 2 had highest HW followed by districts 3 and 4, with lower mean value of HW was noticed in District 1. Sreenivasu *et al.* (2003), Arora *et al.* (2007) and Tailor and Yadav (2011) also reported significant effect of Mandal and districts on HW of adult sheep.

## **5.4 REPRODUCTIVE TRAITS**

### **5.4.1 MEAN VALUES**

#### **5.4.1.1 AGE AT FIRST LAMBING**

Age at first lambing is an important metric trait in determining the overall reproduction as productive life of sheep.

The overall mean of AFL was  $642.14 \pm 2.95$  days. This is in agreement with the report of Rai *et al.* (1988) in Mandya sheep. However, the present estimate was lower than those reported by Narayanaswamy *et al.* (1976) and Siddalinga Murthy (2001) in Bandur sheep, Purushotham (1992), Krishna Reddy *et al.* (1984) in Nellore and Ramesh Gupta and Krishna Reddy (1986) in Mandya Sheep.

Early lambing is most desirable as this would ensure higher life time lamb production compared to the sheep lambing at later age. Early lambing in the present study might be due to improved managerial and better feeding practices of animals.

#### **5.4.1.2 LAMBING INTERVAL**

The period between two consecutive lambings is called as lambing interval, which is an important measure of reproductive efficiency of the ewe. Reduced LI results in more number of lambs in the lifetime of a ewe.

The overall mean LI observed was  $249.66 \pm 0.56$  days. This value is in close proximity with the reports of Poonia (2008) in Munjal sheep. The present findings were much lower than the earlier findings of Narayanaswamy *et al.* (1976), Rai *et al.* (1988) in Mandya sheep and Siddalinga Murthy (2001) in Bandur sheep.

The present findings indicate that reproductive trait of Bandur sheep recorded in native tract are optimum compared to many indigenous sheep of Karnataka. The reason may be selection and culling practiced against late breeders over the years had lead to reduced lambing interval along with better management and nutrition provided to the ewes.

## **5.4.2 EFFECT OF NON-GENETIC FACTOR**

### **5.4.2.1 EFFECT OF DISTRICT**

#### **5.4.2.1.1 AGE AT FIRST LAMBING**

The AFL was significantly influenced by place of sheep. The ewes in D<sub>4</sub> had lower AFL than those placed in D<sub>1</sub>, D<sub>2</sub> and D<sub>3</sub>. Tailor *et al.* (2007) in Sonadi and Kumaravelu and Serma Pandian (2012) in Local sheep have also reported significant effects of location on age at first lambing. However, Patro *et al.* (2006) reported non-significant influence of place of sheep on AFL.

#### **5.4.2.1.2 LAMBING INTERVAL**

The LI was significantly influenced by place or district of sheep. The ewes of D<sub>3</sub> had lower LI than those in other three districts. This finding was closer to the report of Patro *et al.* (2006) and Kumaravelu and Serma Pandian (2012) in Local sheep. Tailor *et al.* (2007) reported non-significant influence of district on LI.

## **5.5 HERITABILITY ESTIMATES ( $h^2$ )**

### **5.5.1 THREE MONTHS WEIGHT**

The heritability estimate of three month BW was  $0.21 \pm 0.09$ . This value is comparable with the reports of Kumar and Tomar (1982), Kulkarni and Deshpande (1986a) and Maroof Ahmad *et al.* (2005) in different breeds of sheep. However, higher heritability estimates were reported by Dafalapurkar *et al.* (1980), Singh and Singh (1997) and Rajendran (2005) in various breeds of sheep.

### **5.5.2 SIX MONTHS WEIGHT**

A very high  $h^2$  value was obtained for six month weight ( $0.81 \pm 0.23$ ) in the present study, which closely tallied with the reports of Sharma *et al.* (2003a) and Mishra *et al.* (2009) in different breeds of sheep. The estimate was however higher than the values of  $0.52 \pm 0.09$  reported by Dixit *et al.* (2001) and  $0.60 \pm 0.05$  by Iyue (1993).

The very high heritability value indicates that there is ample scope for genetic improvement of six month weight through selection and breeding plans. High value may also be attributed to the introduction of new sires periodically into the flock and thereby increasing the genetic variation within farmers' flocks.

### **5.5.3 NINE MONTHS WEIGHT**

The estimated heritability value for nine month weight was  $0.18 \pm 0.07$ . This value is comparable with the reports of Daflapurkar *et al.* (1980) in Pattanwadi breed, Reddy *et al.* (1983) in Nellore sheep and Kirmani *et al.* (1986) in South down sheep.

However, highly heritability estimates were reported by Pannerselvam (1993) ( $0.68 \pm 0.19$ ) and Iyue (1993) ( $0.58 \pm 0.06$ ) in Niligiri and Niligiri synthetic sheep.

The lower estimates were attributable to the fact, that more environmental variation and a lower genetic base was observed for the trait, pointing to the possibility of trait is influenced by environment more.

#### **5.5.4 TWELVE MONTHS WEIGHT**

The heritability estimate for twelve month weight was  $0.72 \pm 0.06$  which was closer to the estimates reported by Iyue (1993) as  $0.64 \pm 0.06$  and Bassett *et al.* (1967) as  $0.82 \pm 0.26$  in different breeds of sheep. The estimate was however higher than the values reported by Pannerselvam (1993) in Nilagiri and Dixit *et al.* (2001) in Bharat Merino.

The present study reveals availability of considerable amount of additive genetic variance that could be exploited to enhance the twelve month weight in future generations.

### **5.6 CORRELATION**

#### **5.6.1 SIX MONTHS**

##### **5.6.1.1 BODY WEIGHT AND BODY MEASUREMENT**

The body weight and body measurement had highly significant ( $P \leq 0.01$ ) positive correlation among six month sheep. The correlation of BW with CG was  $0.82 \pm 0.03$  and with BL was  $0.75 \pm 0.04$ . These findings were in agreement with the reports of Singh and Singh (1974) in Bikaneri lambs and Basu Thakur *et al.* (1980) in Malpura lambs, Bhadula *et al.* (1980) in Muzzafarnagari lambs, Vimal Selvaraj *et al.* (2002) in Madras Red lambs (0.82, 0.83 and 0.88). However, Malik *et al.* (1970) reported a positive but non-significant relationship between the body weights and body measurements (BW, with CG, BL and HW) in Magra lambs.

The high correlations between body weight and CG would imply that live weight could be predicted fairly accurately from CG in six month sheep.

### **5.6.1.2 AMONG BODY MEASUREMENTS**

Chest girth was positive and highly ( $P \leq 0.01$ ) significantly correlated with BL and HW ( $0.82 \pm 0.03$  and  $0.53 \pm 0.06$ ). The result confirms the results of Afolayan *et al.* (2006) in Yankasa sheep, Vimal Selvaraj *et al.* (2002) in Madras Red sheep and Ramana Reddy *et al.* (2002) in Deccani sheep (0.63 and 0.56). Further, BL was also associated positively and highly significantly with HW ( $0.76 \pm 0.04$ ). Similar findings were earlier reported by Singh *et al.* (1972) between BL and HW (0.73) in Bikaneri sheep, Khan and Bhat (1981) in Muzzafarnagari lambs (0.68) and Gajbhiye and Johar (1985) in Magra lambs (0.64).

The correlation coefficient observed in the present study indicates possibility of all traits being controlled by same set of genes functioning in the same direction. Higher positive correlation of CG with BW at six months as well as with other measurements indicates possibility of utilizing CG for prediction of BW.

## **5.6.2 TWELVE MONTHS**

### **5.6.2.1 BODY WEIGHT AND BODY MEASUREMENT**

The correlation coefficient between BW and body measurements was highly positive and significant ( $P \leq 0.01$ ). The coefficient of correlation for BW with CG, BL and HW were  $0.76 \pm 0.01$ ,  $0.50 \pm 0.03$  and  $0.23 \pm 0.03$ , respectively. These values are in close agreement with the earlier reports of Siddalinga Murthy (2001) in Bannur sheep, with values reported as 0.68, 0.66 and 0.58 respectively. Narasimham (2002) reported highly significant association of BW with CG, BL and HW (0.55 to 0.91) in

Nellore sheep, and Sreenivasu *et al.* (2003) reported values of 0.67, 0.42 and 0.42, respectively, in Deccani sheep.

In the present study chest girth is highly significantly correlated with BW which can be possibly useful in prediction of BW. Hence selection for chest girth in sheep would lead to increase in body weight.

#### **5.6.2.2 AMONG BODY MEASUREMENTS**

Positive and highly significant ( $P \leq 0.01$ ) correlation of CG with BL and HW was observed, which were 0.74 and 0.79 respectively. This report substantiates observation of Wadyal and Balaine (1971) in Nali and Lohi breeds, Siddalinga Murthy (2001) in Bandur sheep and Sreenivasu *et al.* (2003) (0.50 and 0.51) in Deccani sheep.

Similarly BL was also associated positively and significantly ( $P \leq 0.01$ ) with HW ( $0.50 \pm 0.02$ ) which confirms the reports of Wadayal and Balaine (1971) in Nali and Lohi breed, Siddalinga Murthy (2001) in Bandur sheep and Sreenivasu *et al.* (2003) in Deccani sheep

The values observed indicated high and significant correlation of CG with BW and body measurements were highly positively significant. Hence, selection for higher chest girth would lead to improvement in other body measurements and body weights, and can be used as a selection criteria.

#### **5.7 PREDICTION EQUATION FOR ESTIMATION OF BODY WEIGHT**

The accuracy of functions used to predict live weight or growth characteristics from measurements on live animals contributes immensely to sheep production. The ability of producer and buyers of meat animals to relate live animal measurements to

growth characteristics is essential for optimum production and value based trading system.

Multiple regression equations were developed for predicting body weight at six and twelve month from respective body measurements using CG, BL and HW as independent variables ( $X_1$ ,  $X_2$  and  $X_3$ ) and body weight (BW) as dependent variable (Y).

### **5.7.1 SIX MONTHS**

The prediction equation developed for six month body weight was found to be efficient when CG ( $X_1$ ) was used in combination with BL and HW for fitting the equation. The  $R^2$  values obtained ranged from 69.49 to 70.49 per cent. The contribution of BL ( $X_2$ ) with HW ( $X_3$ ) for fitting equation resulted with an efficiency of 56.94 per cent.

In the present study, contribution of CG in all the four equations was highly significant ( $P \leq 0.01$ ) with higher  $R^2$  value. Similar inferences were made by Bhat *et al.* (1980) in prediction at 8<sup>th</sup> week and 13<sup>th</sup> week age in Muzzafarnagari sheep, Vimal Selvaraj *et al.* (2002) concluded that CG is the best index to make prediction of body weights in Madras Red sheep at different age groups(3, 6, 9 and 12 months). Afolayan *et al.* (2006) concluded that CG accounted for 89 per cent variation in body weight with higher precision and reliable measurement for prediction of body weights. While Nagaraja *et al.* (1996) concluded that body height and length contributed significantly for prediction of six month (90.18%) live weight in Bannur sheep.

### **5.7.2 TWELVE MONTHS**

The coefficient of determination of the fitted multiple regression equation for prediction of body weights of sheep at twelve month ranged from 32.39 to 60.54 per

cent. The equation CG ( $X_1$ ) had highly significant influence and contribution for predicting live weight at twelve month age also. This observation was in agreement with the inferences of Vimal Selvaraj *et al.* (2002) and Afloyan *et al.* (2006) in different breeds of sheep.

In the present study, the results of multiple regression analysis indicated that CG ( $X_1$ ) in combination with BL ( $X_2$ ) and HW ( $X_3$ ) would result in significant improvements in accuracy of predictions. Also, the best equations for predicting body weight were obtained when all three body measurements were considered in the equation where  $R^2$  values were high at both the age groups, indicating BL and HW also contributed for prediction of BW ( $Y$ ) along with CG.

## CONCLUSIONS

- 1) In the present study breed morphological characters noted were coat colour predominantly white colour with light brown face usually extending up to neck. Head profile is straight to slightly convex, ears medium length in size and drooping, with wattles absent in majority of sheep. Tail length was medium and predominantly horns were absent in Bandur sheep.
- 2) The study concludes that the adult Bandur sheep maintained in field under grazing and tethering system were equally efficient in growth as those maintained at organized farm. While body weight at third month was observably less. Hence it is suggested for improvement of third month weight by appropriate selection and breeding along with better care and nutrition.
- 3) The study noted that the recorded age at first lambing and lambing interval were better than many recognized breeds in Karnataka under field conditions.
- 4) Selection for higher chest girth will lead to improvement in body measurements and body weights. Prediction equations indicated that chest girth in combination with other body measurements would significantly improve the accuracy of prediction of body weights at six and twelve months of age.



# **SUMMARY**

## VI. SUMMARY

The present investigation was contemplated with the objectives, to compile information on morphological traits of Bandur sheep in the home tract, to assess performance of growth and reproductive traits, to predict body weight at six and twelve months of age based on body measurements and to estimate heritabilities of traits of economic importance.

Data for the present study were collected from Bandur sheep maintained by the sheep farmers in its breeding / home tract from selected taluks of Mandya, Mysore, Bangalore (Rural) and Kolar districts of Karnataka. A detailed stratified random sampling of farmer's household intensive survey was conducted involving 116 villages distributed in 13 taluks of four districts

Data pertaining to morphological, body weights, body measurements at different ages and reproductive traits like inter lambing period, age at first lambing were recorded on Bandur sheep from the four districts. The data pertaining to the reproductive traits were collected from 1004 lambing of 1500 ewes for age at first lambing and 868 lambing records for lambing intervals.

The predominant colour was white with light brown face which was observed in 75.20 per cent of the total observed sample population while the other colours observed were dull white and light brown markings (23.20 per cent), and dull brown with white patches (1.6 per cent).

The forehead was convex in 1646 sheep (62.27%), while concave forehead was noticed in 609 (23.20%) and straight forehead in 1.6 per cent of total sheep.

The tassles/wattles were absent in 67.39 per cent (1769), wattles were present in 856 sheep (32.61%) of the sampled survey population. The beard was absent in 85.37 per cent of the population. Curved tail was observed in 58.86 per cent of the animals studied while the remaining 41.41 per cent had straight tail.

The sheep mainly possessed medium length tail (71.81%), while 22.63 per cent surveyed sheep were short tailed and 5.56 per cent sheep were long tailed.

Bandur sheep was characterized with 68.72 per cent of the animals being hornless adult. The percentage of horned sheep was 31.28 per cent (821) of the total. Among 821 horned sheep, horn colour was black in 53.78 per cent, white in 4.07 per cent and brown in 19.48 per cent. Shape of the horns was mostly straight (66.26%), while curved was noticed in 33.74 per cent of the surveyed adult population.

The ear orientation expressed in the sheep studied was mainly pendulous (67.75%), while erect and horizontally oriented ears was noticed in 17.02 per cent and while 15.43 per cent of the animals.

The overall least square means obtained for body weight at three months was  $4.79 \pm 0.09$  kg. The influence of sex was found to be non-significant ( $P > 0.05$ ). The least square analysis of variance indicated significant ( $P \leq 0.05$ ) effect of district. Lambs located in Mysore district were found to be heavier.

The overall mean obtained for six months body weight was  $11.40 \pm 0.13$  kg, and was significantly affected by sex ( $P \leq 0.05$ ). A significantly higher BW was recorded in Mandya District followed by Mysore District. There was significant difference among the means of different districts ( $P \leq 0.05$ ). The overall mean body

weight of nine month Bandur sheep was  $15.86 \pm 0.07$  kg. The effect of sex and districts were found to be non-significant ( $P > 0.05$ ).

The overall mean obtained for twelve month body weight was  $26.13 \pm 0.11$  kg. The observed differences among sexes of twelve months body weight was significant ( $P \leq 0.05$ ). The overall mean body weight of adult sheep was  $28.28 \pm 0.04$  kg. The observed differences among adult body weights of different sexes was significant ( $P \leq 0.05$ ). Ewes were significantly heavier than rams. There was significant difference among the means of different districts.

The overall mean values for CG (cm), BL (cm) and HW (cm) of the sheep were respectively  $45.21 \pm 1.22$ ,  $56.89 \pm 0.40$ ,  $71.40 \pm 0.25$ ,  $77.65 \pm 0.18$  and  $75.98 \pm 0.16$  cm,  $41.58 \pm 0.49$ ,  $51.20 \pm 0.77$ ,  $53.18 \pm 0.24$ ,  $61.74 \pm 0.95$  and  $63.64 \pm 0.13$  cm and  $42.66 \pm 0.54$ ,  $45.9 \pm 0.47$ ,  $48.52 \pm 0.08$ ,  $52.20 \pm 0.11$  and  $53.90 \pm 0.10$  cm respectively in age groups 3, 6, 9, 12 month and adult sheep in the study.

The effect of sex was found to be significant for ( $P < 0.05$ ) CG of three (ewes had higher CG), six, nine and twelve month and adult rams and ewes. Rams had higher CG than ewes among nine and twelve month sheep.

There was no significant difference noted among the least square means of CG for three month lambs and in adults born in various districts. There were significant differences among the least square means of CG in six, nine and twelve month lambs placed at various districts.

The observed differences among BL of different sexes were significant ( $P \leq 0.05$ ) difference was observed between the means of male and female sheep of all the age group in the present study.

Significant difference were observed between the means of BL of three, twelve month and adult sheep placed at different districts ( $P>0.05$ ). The mean BL differences among the six and nine month sheep between the districts were non-significant ( $P>0.05$ )

The effect of sex was non-significant on HW among three month lambs ( $P\geq 0.05$ ). The mean differences of HW between the sexes were significant ( $P\leq 0.05$ ) among six, nine, twelve month and adult sheep. The difference between the sexes was significant with ewes having higher HW in adult sheep.

The differences in the means of HW among three month lambs were statistically non-significant ( $P>0.05$ ) between districts. While there were significant differences of HW between the means of different districts among six, nine, twelve month and adult sheep

The overall mean obtained for age at first lambing was  $642.14 \pm 2.95$  days and the overall lambing interval was  $249.66 \pm 0.56$  days. The difference observed among means between the districts were significant ( $P\leq 0.05$ ).

The data was screened and selected based on single ram flocks as per the information of farmers with at least three progenies in the same age group .The heritability estimates of BW was  $0.21 \pm 0.09$ ,  $0.82 \pm 0.23$ ,  $0.19 \pm 0.07$  and  $0.72 \pm 0.06$  for three, six, nine and 12 months, respectively.

The association of six month lambs BW with body measurements were positive and highly significant ( $P\leq 0.01$ ) and moderate to high correlation estimates were noted for BW with CG, BL and HW of  $0.82 \pm 0.03$ ,  $0.75 \pm 0.04$  and  $0.61 \pm 0.0$ , respectively. Association between twelve month BW and body measurement were

positive and highly significant ( $P \leq 0.01$ ), the coefficient of correlation estimates with CG, BL and HW being  $0.76 \pm 0.01$ ,  $0.50 \pm 0.02$  and  $0.23 \pm 0.03$  respectively.

The coefficient of correlation in six months lambs between all the three body measurements were positive and highly significant ( $P \leq 0.01$ ). The correlation of CG with BL and HW were  $0.82 \pm 0.03$  and  $0.58 \pm 0.06$ , respectively. In yearlings, the coefficient of correlation between body measurements observed correlation values for CG between BL and HW were  $0.74 \pm 0.02$  and  $0.79 \pm 0.01$ , respectively.

All the three body measurements contributed significantly to the expression of body weights among six month sheep and the  $R^2$  value of the single fitted multiple regression equation involving was 70.49 per cent. The contribution of BL and HW in combination as single fitted regression equation was significant with  $R^2$  value of 56.94 per cent. The linear regression equation carried out to predict body weight using chest girth( $x_1$ ) was significant with  $R^2$  value of 54.02 per cent.

The  $R^2$  value of the fitted multiple regression equations for the prediction of BW of twelve month sheep ranged from 32.39 to 60.54 per cent. It was observed that the partial regression coefficient involving all the three variables ( $X_1, X_2, X_3$ ) was more efficient with a higher  $R^2$  value of 60.54 per cent. The  $R^2$  value of the single fitted linear regression equation involving single variable ( $X_1$ ) was 51.28 per cent.



# **BIBLIOGRAPHY**

## VII. BIBLIOGRAPHY

- Acharya, R.M. and Bhat, P.N., 1984, Livestock and poultry genetic resources in India. Publication and Information Section, Indian Veterinary Research Institute, India.
- Acharya, R.M. and Malik, R.C., 1971, Genetic and phenotypic parameters for pre and post weaning body weight in Nali and Lohi and their crosses with Nellore and Mandya. *Indian J. Anim. Sci.*, **41** : 1126-1129.
- Acharya, R.M., 1982, Sheep and Goat Breeds of India. FAO Animal Production and Health paper, **30**, FAO, Rome, Italy.
- Afolayan, R.A., Adeyinka, I.A. and Lakpini, C.A.M., 2006, The estimation of live weight from body measurements in Yankasa sheep. *Czech J. Anim. Sci.*, **51**(8) : 343-348.
- Akhtar, P., Abdullah, M., Younas, M. and Mirza, M.A., 2007, Heritability estimates of some growth traits of Hissardale sheep in Pakistan. *Indian J. Anim. Sci.*, **77** : 181-183.
- Anonymous, 2004a,. Survey and evaluation report of Mecheri sheep. Tamil Nadu Veterinary and Animal Sciences University, Chennai and NBAGR, Karnal
- Anonymous, 2004b, Survey and evaluation report of Deccani sheep. BAIF, Pune. and NBAGR, Karnal.
- Anonymous, 2006, Sheep genetic resources of India, Coimbatore sheep. NBAGR, Karnal.
- Anonymous, 2007, 18<sup>th</sup> Quin-qinneeal livestock census report, Department of Animal Husbandry and Veterinary Services, Government of Karnataka

- Anonymous, 2008, Breed descriptors of sheep (special feature). National Bureau of Animal Genetic Resources, Karnal. *Indian J. Anim. Sci.*, **78**(9) : 1039-1045.
- Anonymous, 2010, Basic Animal Husbandry Statistics, *AHS series 12*. Ministry of Agriculture, Department of Animal Husbandry Dairying and Fisheries, Government of India.
- Anonymous, 2011-12, Integrated sample survey for estimation of production of milk, egg, wool and meat, Department of Animal Husbandry and Veterinary Services, Government of Karnataka.
- Anonymous, 2013, Breed descriptor of sheep (special features). National Bureau of Animal Genetic Resources, Karnal. *Indian J. Anim. Sci.*, **83**(2) : 108-124.
- Arora, C.L. and Acharya, R.M., 1976, Improvement of Mandya sheep in Karnataka : A review. *Indian J. Anim. Sci.*, **46** : 340-345.
- Arora, A.L. and Swarnkar, C.P., 1995, Factors affecting age and weight at first breeding and first lambing in Malpura ewes. *Indian J. Small Rumin.*, **1** : 22-25
- Arora, C.L., Acharya, R.M., Badshiya, B.S. and Dass, N.C., 1975a, Characterization of Chokla breed in Rajasthan and future prospects for its improvement. *Indian J. Anim. Sci.*, **45**(6) : 345-350.
- Arora, C.L., Acharya, R.M., Badshiya, B.S. and Dass, N.C., 1975b, Characterization of Malpura breed in Rajasthan and future prospects for its improvement. *Indian J. Anim. Sci.*, **45** : 843-848.
- Arora, C.L., Acharya, R.M., Singh, R. and Buch, S.D., 1975c, Characterization of Nali breed in Rajasthan and future prospects for its improvement. *Indian J. Anim. Sci.*, **45** : 849-855.
- Arora, C.L., Acharya, R.M., Sangolli, B.V. and Nagaraja, M.S., 1977, Characterization of Sonadi breed in Rajasthan and future prospects for its improvement. *Indian J. Anim. Sci.*, **47** : 120-125.

- Arora, C.L., Mishra, R. K. and Gupta, D.C., 1983, Variation in the growth traits of Nali, Chokla and their half-breds with Rambouillet and Merino sheep. *Indian Vet. J.*, **60** : 111-117.
- Arora, R., Bhatia, S., Monika Sodhi, Gautam Sahana, Manishi Mukesh and Ahlawat, S.P.S., 2005, The profile microsheep of India "Garole". NBAGR, Karnal.
- Arora, A.L., Prince, L.L.L. and Mishra, A.K., 2007, Performance evaluation of Jaisalmeri sheep in farmers' flocks. *Indian J. Anim. Sci.*, **77**(8) : 759-762.
- Arora, R., Bhatia, S. and Jain, A., 2008, Assessment of breed characters and genetic diversity of an important Mutton sheep breed from Orissa. ARD-202. Compendium of National Symposium on Redefining Role of Indigenous Animal Genetic Resources in Rural Development. p. 169.
- Atkins, K.D., 1986, A genetic analysis of the components of lifetime productivity in Scottish Blackface sheep. *Indian J. Anim. Sci.*, **43** : 405-419.
- Balasubramanyam, D. and Kumarasamy, P., 2011, Performance of Madras Red sheep in Kancheepuram district. *Indian J. Fundamental and Applied Life Sciences*, **1**(2) : 133-137.
- Bappaditya Dey and Poonia, J.S., 2005, Reproductive performance of Nali sheep. *Indian J. Small Rumin.*, **11**(1) : 10-13.
- Basset, J.W., Cartwright, T.C., Van Horn, J.L. and Willson, F.S., 1967, Estimates of genetic and phenotypic parameters of weaning and yearling traits in range Rambouillet ewes. *J. Anim. Sci.*, **26** : 254-260.
- Basu Thakur, A.K. and Negi, G.C., 1968, A study of phenotypic biometry of indigenous Rampur Bushair sheep. *Indian Vet. J.*, **38** : 258-260.
- Basu Thakur, A.K. and Singh, O.N., 1969, A study on body weight and conformation of Coimbatore and Corriedale sheep. *Indian Vet. J.*, **46** : 1065-1068.
- Basu Thakur, A.K., Mahajan, J.M. and Singh, O.N., 1967, Study on body weight and conformation of Gaddi and Romney Marsh sheep. *Indian Vet. J.*, **44** : 589-596.

- Basu Thakur, A.K., Nivasarkar, A.E. and Singh, R.N., 1980, Studies on some pre and post slaughter parameters in Malpura lambs 1. Phenotypic biometry and dressing percentage. *Indian Vet. J.*, **57** : 473-478.
- Becker, W.A., 1975, Manual of Quantitative Genetics (3<sup>rd</sup> edn.). Washington State University, Pullman, Washington, pp xi + 170.
- Bhadula, S.K. and Bhat, P.N., 1980a, Genetic and non-genetic factors affecting body weight in Muzaffarnagari sheep and their half-breds. *Indian J. Anim. Sci.*, **50** : 582-856.
- Bhadula, S.K. and Bhat, P.N., 1980b, Genetic and phenotypic parameters of body weights in Muzaffarnagari sheep and their Corriedale half-breds. *Indian J. Anim. Sci.*, **50** : 1094-1097.
- Bhadula, S.K., Bhat, P.N. and Garg, R.C., 1979, Prediction of body weight from body measurements in sheep. *Indian J. Anim. Sci.*, **49**(10) : 775-777.
- Bhadula, S.K., Bhat, P.N. and Garg, R.C., 1980, Note on the estimates of heritability and phenotypic correlations of weight and linear body measurements in Muzaffarnagari sheep. *Indian J. Anim. Sci.*, **50** : 573-575.
- Bhasin, N.R., Desai, R.N. and Kapri, B.D., 1968, Studies on body size in relation to clean fleece yield in Bikaneri sheep. *Indian Vet. J.*, **38** : 632-643.
- Bhat, P.N., Bhat Pran, P. and Garg, R.C., 1980, Note on predicting pre-weaning weights using linear body measurements in sheep. *Indian J. Anim. Sci.*, **50** : 657-659.
- Boujenane, I. and Kerfal, M., 1990, Estimates of genetic and phenotypic parameters for growth traits of D'man lambs. *Anim. Prod.*, **51** : 173-178.
- Chandran, P.C., 1998, Characteristics and performance of Vembur sheep in the Habitat. M.V.Sc. Thesis submitted to Tamil Nadu Veterinary and Animal Sciences University, Chennai, India.

- Chopra, S.C. and Acharya, R.M., 1971, Genetic and phenotypic parameters of body weights in Bikaneri sheep (Magra strain). *Anim. Prod.*, **13** : 343-347.
- Daflapurkar, D.K., Kaushik, S.N. and Katpatal, B.G., 1980, Hereditary and environmental variations in body weight at different ages in cross-bred sheep. *Indian Vet. J.*, **57** : 43-51.
- Dass, G., 2006, Pugal sheep : 1. Growth, wool production and wool quality parameters under field conditions. *Indian J. Small Rumin.*, **12** : 152-155.
- Dass, G., 2007, Pugal sheep : 1. Growth, wool production and wool quality parameters under field conditions. *Indian J. Small Rumin.*, **12(2)** : 52-55.
- Dass, G.S. and Acharya, R., 1970, Growth of Bikaneri sheep. *J. Anim. Sci.*, **31** : 1-4.
- Dass, G. and Hariprasad, 2007, Morphological characteristics, live weights and management practices of Muzaffarnagari sheep in the home tract. *Indian J. Small Rumin.*, **13(1)** : 27-30.
- Dass, G. Singh, V.K., Chopra, S.K., Sharma, P.R. and Vimal Mehrotra, 2004, Marwari : An important sheep breed of arid and semi arid region of India (AGR 005). Proceedings of National Symposium on livestock biodiversity vis-à-vis resource exploitation : An introspection. P.123
- Dayananda, N.G., 1998, Evaluation of local strain of sheep in Tumkur district of Karnataka for economic traits. M.V.Sc. Thesis, Univ. Agric. Sci., Bangalore.
- Devendran, P., Cauveri, D. and Gajendran, K., 2008, Growth performance of Madras Red sheep in farmer's flocks. Compendium:- Abstract presented in IX Annual Conference of Indian Society of Animal Genetics and Breeding and National Symposium on "Livestock Genomics in Productivity Enhancement for Food Security". New Delhi, India.

- Devendran, P., Kandasamy, N. and Panneerselvam, S., 2008, Distribution and breed characteristics of Coimbatore sheep. Compendium of National Symposium on Redefining role of indigenous animal genetic resources in Rural Development. pp. 171-172.
- Dikshit, R.K., 1981, Genetic and non-genetic studies on pre-weaning traits in Bannur lambs. M.V.Sc. Thesis submitted to UAS, Bangalore.
- Dinesh Kumar, Gurmej Singh and Anand Jain, 2006, Characterization and evaluation of Muzaffarnagri sheep. *Indian J. Small Rumin.*, **12**(1) : 48-55.
- Dixit, S.P., Dhillon, J.S. and Singh, G., 2001, Genetic and non-genetic parameter estimates for growth traits of Bhart Merino lambs. *Small Rumin. Res.*, **42** : 101-104.
- Dixit, S.P., Gaur, G.K., Yadav, D.K. and Singh, G., 2005, Characterization of the Rampur Bushair sheep in the north temperate region of India. *Animal Genetic Resources Information*, **36** : 47-52.
- Dzakuma, J.M., Nielsen, M.K. and Doane, T.H., 1978, Genetic and phenotypic parameter estimates for growth and wool traits in Hampshire sheep. *J. Anim. Sci.*, **47** : 1014-1021.
- Ercanbrack, S.K. and Price, D.A., 1972, Selecting for weight and rate of gain in non-inbred lambs. *J. Anim. Sci.*, **34** : 713-725.
- Gajbhiye, P.U. and Johar, K.S., 1985, Predicting body weight on the basis of body measurements in Magra sheep. *Indian J. Anim. Sci.*, **55**(7) : 604-606.
- Ghalasasi, P.M. and Nimbkar, B.V., 1993, The "Garole" micro sheep of Bengal. *Anim. Genet. Res. Inform.*, **12** : 73-79.

- Ghalasasi, P.M., Nimbkar, C. and Gray, G.D., 1994, Garole-Prolific microsheap of West Bengal, India. In : Smith, C., Gavora, J.S., Benkel, B., Chesnais, J., Fairfull, W., Gibson, J.P., Kennedy, B. and Burnside, E.B.(Eds.), Proceedings of fifth World Congress on Genetics applied to livestock production, University of Guelph, Guelph, Ontario, Canada, 7-12 August 1994 pp. 456-459.
- Ghanekar, V.M., Bhatawadekar, S.D. and Gholap, L.D., 1973, Biometry study of Patanwadi x Deccani sheep. *Indian Vet. J.*, **50** : 339-342.
- Govindaiah, M.G., Jayashankar, M.R. and Anand Jain, 2006, Network project on survey, evaluation and characterization of Mandya sheep breed. *Final Report*. Department of Animal Breeding, Genetics and Biostatistics, Veterinary College, KVAFSU (B), Regional Campus, Hebbal, Bangalore.
- Gupta, K., Kaila, I.P., Thakur, Y.P. and Katoch, S., 2004, Growth pattern studies of Gaddi sheep in cold arid zone of Himachal Pradesh (AGR126). Compendium of National Symposium on Livestock biodiversity vis-à-vis resource exploitation : An introspection. p. 187.
- Harvey, W.R., 1987, Least-squares analysis of data with unequal subclass number. A.R.S.20. United States ,Dept. Of Agriculture, Washington,D.C.
- Iyue, M., 1993, Genetic and phenotypic evaluation of Nilagiri synthetics. Ph.D. Thesis submitted to Tamil Nadu Veterinary and Animal Sciences University, Chennai, India.
- Jagatheesan, P.N.R., Arunachalam, S., Sivakumar, T. and Selvaraju, M., 2003, Performances of Mecheri sheep in its breeding tract. *Indian J. Anim. Sci.*, **73** : 909-912.
- Jagatheesan, P.N.R., Arunachalam, S., Sivakumar, T. and Selvaraju, M., 2004, reproductive performances of Mecheri sheep in its home tract. *Indian Vet. J.*, **81** : 109-111.

- Jain. A and Gurmej Singh, 2008, Balangir-an imperative sheep breed of Orissa. Compendium of National Symposium on Redefining role of indigenous animal genetic resources in Rural Development. pp. 159-160.
- Jain. A, 2004, Status of sheep genetic resources of India (AGRI47). Compendium of National Symposium on Livestock biodiversity vis-à-vis resource exploitation : An introspection. p. 93.
- Jain. A, Govindaiah, M.G., Sadana, D.K., Kulkarni, V.S., Aswathnarayan, T., Pandey, A.K., Rekha Sharma, Dinesh Kumar, and Ahlawat, S.P.S., 2006, Sheep genetic resources of India, Hassan breed. NBAGR, Karnal.
- Jain.A, Kulkarni, V.S., Govindaiah, M.G., Sadana, D.K., Aswathnarayan, T., Pandey, A.K., Dinesh Kumar, Rekha Sharma and Gurmej Singh, 2005, Sheep genetic resources of India, Bellary breed. NBAGR, Karnal.
- Jayashankar, M.R., Goivndaiah, M.G., Naveen, Kumar, S., Anand Jain and Darshan Raj, G., 2008, Biometrical profile of Mandya sheep breed. *Compendium of National symposium on Redefining role of indigenous animal genetic resources in Rural Development*, February 15-16, 2008. SOCDAB and KVAFSU-Bidar at Bangalore campus. pp. 209-210.
- John, B. Owen, 1976, Sheep production. The English Language Book Society and Bailiere Tindall London. pp. 196-198.
- Kaila, O.P., Sinha, N.R. and Khan, B.U., 1989, Body weight growth in Muzaffarnagari sheep and its exotic crossbreds. *Indian J. Anim. Sci.*, **59** : 877-880.
- Kandasamy, N. and Gupta, D.C., 1983, Studies on physical measurements, live weight and fleece weight in native and crossbred sheep in a semi-arid zone of India. *Tropical Agriculture (Trinidad)* : **60** : 92-94.

- Kandasamy, N., Devendran, P., Panneerselvam, S., Thiruvankadan, A.K., Singh, G., Singh, P.K. and Ahlawat, S.P.S., 2006, Coimbatore sheep, Monograph. National Bureau of Animal Genetic Resources, Karnal and Tamil Nadu Veterinary and Animal Sciences University, Chennai, India.
- Karunanithi, K., Purushothaman, M.R., Thiruvankadan, A.K., Singh, G., Sadana, D.K. and Murugan, M., 2005, Breed characteristics of Mecheri sheep. *Animal Genetic Resources Information*, **37** : 53-62.
- Kaushish, S.K., 1994, Sheep production in the tropics and subtropics. Scientific Publishers, Jodhpur, pp. 42-43.
- Khan, B.U. and Bhat, P.N., 1981, Genetic and non-genetic factors affecting live lamb traits in Muzaffarnagari sheep and its half-breds with Corriedale. *Indian J. Anim. Sci.*, **51** : 39-48.
- Kirmani, M.A., Singh, H., Singh, V. and Chaudhary, R.P., 1986, The estimates of certain genetic parameters in Hampshire, Southdown and Polled Dorset breeds of sheep. *Indian J. Anim. Sci.*, **20** : 19-24.
- Krishna Reddy, A., Sharma, P.L.N., Rao, V.P. and Dutta, O.P., 1984, The influence of non-genetic factors on reproductive traits in Nellore sheep. *Indian Vet. J.*, **6** : 59-63.
- Krishna Reddy, K. and Rai, A.V., 1987, Factors affecting post weaning (6-12 months) body weights of Mandya, Nellore and their half breeds with Dorset Horn and Suffolk breeds. *Indian Vet. J.*, **64** : 677-682.
- Krishna Reddy, K., 1983, Genetic studies on growth and reproduction in Mandya and Nellore and their half-breds with Dorset and Suffolk. Ph.D. Thesis, Univ. Agric. Sci., Bangalore.
- Krishnappa, S.B., 1979, Comparative study of Deccani with Corriedale x Deccani crosses of sheep. Thesis submitted to University of Agricultural Sciences, Bangalore.

- Krishnappa, S.B., Balbir Singh and Balaine, D.S., 1983, Comparative profiles of body size in Nali and its crosses with Corriedale and Russian Merino. *Indian J. Anim. Genet. Breed.*, **5**(1-2) : 24-26.
- Kulkarni, A.P. and Deshpande, K.S., 1986a, Factors affecting body weights at different stages and first clip fleece weight in Deccani sheep. *Indian J. Anim. Sci.*, **56** : 971-974.
- Kulkarni, A.P. and Deshpande, K.S., 1986b, Genetic studies on weaning weight and subsequent body weights in Deccani sheep and its crosses. *Indian J. Anim. Sci.*, **56** : 1180-1181.
- Kumar, N., Reheja, K.L. and Bisht, G.S., 1989, Factors affecting growth and female reproductive traits in UAS strain of sheep. *Indian J. Anim. Genet. Breed.*, **11** : 33-39.
- Kumar, S. and Tomar, N.S., 1982, Genetic studies on Corriedale sheep in India. *Indian Vet. J.*, **59** : 948-951.
- Kumar, S., Sharma, R.C., Mishra, A.K. and Arora, A.L., 2003, Production performance of sheep and certain management practices in farmers' flocks of south east Rajasthan. *Indian J. Small Rumin.*, **9** : 103-105.
- Kumaravelu, N. and Serma Saravana Pandian, A., 2012, A study on reproductive performance of sheep in field flocks of Tamil Nadu. *Intl. J. Food, Agri. Vet. Sci.*, **2**(3) : 1-7.
- Kumaravelu, N. and Serma Saravana Pandian, A., 2012, A study on reproductive performance of sheep in field flock of tamil nadu. *Intl. J. Food. Agri.Vet. Sci.*, **2**(3) : 1-7.
- Kushwaha, B.P., Kumar S., Kumar, R., and Mehta, B.S., 1997, Chokla sheep in India. *Animal Genetic Resources Information*, **22** : 19-27.
- Kushwaha, B.P., Mehta, B.S., Sushil Kumar and Kumar, S., 1999a, Survey of Chokla sheep in farmers flock. *Indian J. Small Rumin.*, **5** : 14-19.

- Kushwaha, B.P., Riyazuddin, Singh, R.N. and Parthasarathy, S., 1999b, Characteristics of Munjal sheep. *Animal Genetic Resources Information*, **25** : 27-31.
- Mahajan, J.M. and Bohra, S.D.J., 1977, Some biometrical investigations on the Gaddi Hill breed of sheep. *Indian J. Anim. Sci.*, **11** : 44-46.
- Mali, S.S., Kale, K.M. and Thorat, B.P., 1985, A note on relationship between body measurements in Deccani sheep. *Indian Vet. J.*, **62** : 347-348.
- Malik, B.S., Kunzru, O.N. and Dwaraknath, P.K., 1970, Relationship of birth weight and certain body measurements at birth with yearling body weight of Magra lambs. *Indian Vet. J.*, **47** : 749-752.
- Malik, R.C., Archarya, R.M. and Singh, R.N., 1980, Factors affecting weights from birth to one year in crosses of Chokla, Malpura and Jaisalmeri with Rambouillet. *Indian J. Anim. Sci.*, **50** : 482-492.
- Mandal, A., Pant, K.P., Nandy, D.K., Rout, P.K. and Roy, R., 2003, Genetic analysis of growth traits in Muzaffarnagari sheep. *Trop. Anim. Hlth. Prod.*, **35** : 271-284.
- Mandal, A., Rout, P.K., Roy, R. and Sinha, N.K., 2007, Genetic analysis on growth of body dimensions in Muzaffarnagari sheep. *Indian J. Anim. Sci.*, **77**(9) : 902-906.
- Mani, V., Iyue, M. and Rodricks, I.M., 1982, Production performance of Grozney Merino-3 months weight. *Cheiron*, **11** : 121-125.
- Maroof Ahmad, Singh, C.V., Sharma, R.K., Sushil Kumar and Arora, A.L., 2004, Genetic estimates of growth and wool yield in Avikalin sheep. *Indian J. Small Rumin.*, **10**(2) : 156-158.

- Maroof Ahmad, Singh, C.V., Sharma, R.K., Sushil Kumar and Arora, A.L., 2005, Comparison of different methods of heritability estimates for body weights and wool yield traits in Avikalin sheep. *Indian J. Small Rumin.*, **11**(2) : 121-126.
- Mavrogenis, A.P., Bouca, A. and Robison, O.W., 1980, Estimates of genetic parameters for pre-weaning and post-weaning growth traits of Chios lambs. *Anim. Prod.*, **36** : 271-276.
- Mehta, S.C., Singh, V.K., Ayub, M. and Mehrotra, V., 2003, Growth and reproductive performance of Magra breed of sheep. *Indian J. Anim. Sci.*, **73** : 1147-1149.
- Mehta, S.C., Vij, P.K., Joshi, B.K., Sashi, R. and Nivsarkar, A.E., 1995, Characterisation and conservation of the Malpura sheep breed. *Genetic Resources Information*, **16** : 83-91.
- Mishra, A.K., Arora, A.L., Prince, L.L.L., Sushil Kumar and Gowane, G.R., 2009, Genetic analysis of performance traits of Malpura sheep. *Indian Vet. J.*, **86** : 484-486.
- Mishra, A.K., Arora, A.L., Sushil Kumar and Singh, V.K., 2006, Performance evaluation of Garole sheep in semi-arid region of Rajasthan. *Indian J. Anim. Sci.*, **76**(5) : 393-397.
- Mishra, P.K., Barik, N., Partro, B.N. and Nayak, S., 2004, Production potentiality of Ganjam sheep under extensive management. *Indian J. Small Rumin.*, **10**(2) : 171-172.
- Mittal, J.P., 1988, Breeding characteristics of Marwari goat of western Rajasthan. *Indian J. Anim. Sci.*, **58** : 357-361.
- Mohanty, S.C. and Mishra, M., 1992, Growth performance of Ganjam and Bolangir sheep and prediction of their body weights from body measurements. *Indian J. Anim. Prod. Mgmt.*, **8** : 250-258.

- Mohanty, S.C. and Mishra, M., 1992, Reproductive performance and mortality in Ganjam and Bolangir sheep. *Indian J. Anim. Prod. Mangmt.*, **8**(3) : 160-163.
- Nagaraja, C.S., Govindaiah, M.G., Jayashankar, M.R. and Krishnappa, S.B., 1996, Prediction of body weights from body measurements in Bannur sheep. *Curr. Res.*, **25** : 211-212.
- Naikare, B.D. and Jagtap, D.Z., 1988, Factors affecting body weights in Deccani and its crosses. *Indian J. Anim. Sci.*, **58** : 502-504.
- Naikare, B.D. and Jagtap, D.Z., 1989, Six months body weights of Deccani and Merino halfbreds. *Indian Vet. J.*, **66** : 224-226.
- Narasimham, S.A.L., 2002, Biometrical studies Nellore and Deccani breed of sheep. M.V.Sc. Thesis submitted to Archarya N.G. Ranga Agricultural University, Rajendranagar.
- Narayanaswamy, M., Balaine, D.S. and Chopra, S.C., 1975, Effect of some non-genetic factors on body weights in Mandya sheep. *Indian J. Anim. Sci.*, **45** : 451-453.
- Narayanaswamy, M., Daya Singh Balaine and Balbir Singh, 1976, A note on studies on age at first lambing and lambing interval in Bannur (Mandya) sheep. *Indian J. Anim. Sci.*, **46**(1) : 47-49.
- Nehra, K.S. and Singh, V.K., 2006, Genetic evaluation of Marwari sheep in Arid Zone : Growth. *Indian J. Small Rumin.*, **12** : 91-94.
- Nimbkar, C., 1993, The goats and sheep of the Deccan plateau in Maharashtra state of India. *Anim. Genetic Resources Inform.*, **12** : 81-91.
- Panneerselvam, S., 1993, Genetic studies on growth in Nilagiri sheep. Ph.D. Thesis submitted to Tamil Nadu Veterinary and Animal Sciences University, Chennai, India.

- Patro, B.N., Mallick, C.R., Rao, P.K. and Panda, P., 2006, Production performance of indigenous meat type sheep in Kendrapada district of coastal Orissa. *Indian J. Small Rumin.*, **12**(1) : 42-47.
- Pattanayak, G.R., Patro, B.N., Dass, S.K. and Nayak, S., 2003, Survey and performance evaluation of Ganjam sheep. *Indian J. Small Rumin.*, **9** : 47-49.
- Poonia, J.S., 2004, Growth performance of Munjal lambs. *Indian J. Small Rumin.*, **10**(2) : 137-139.
- Poonia, J.S., 2008, Reproductive performance of Munjal lambs. *Indian J. Small Rumin.*, **14**(1) : 121-123.
- Pradhan, S.L., 1987, A short note on the estimation of live weight of sheep and goats by physical measurement of the body in Nepal. *Nepalese J. Anim. Sci.*, **3** : 27-32.
- Purushotham, C.H., 1972, Comparative study of the production and reproduction traits in Nellore and Mandya sheep. M.V.Sc. Thesis, A.P.A.U., Hyderabad, A.P.
- Rai, A.V., Desai, D.S. and Rao, H.K.R., 1988, Performance of Mandya sheep. *Curr. Res.*, **8**(1) : 11-12.
- Rajendran, R., 2005, Genetic analysis of reproduction traits and survivability of Nilagiri sheep and its synthetic crosses. Ph.D. Thesis submitted to Tamil Nadu Veterinary and Animal Sciences University, Chennai, India.
- Rajkumar, G.P., 1981, Genetic studies on haemoglobin and potassium polymorphism and their relationship with body weights in Bannur sheep. Thesis submitted to University of Agricultural Sciences, Bangalore.
- Raman, K.S., Sundararaman, M.N., Haribhaskar, S. and Ganesakale, D., 2003, Biometrics and breed characteristics of Madras Red sheep. *Indian J. Small Rumin.*, **9** : 6-9.

- Ramana Reddy, Y., Krishna, N., Raghava Rao, E. and Ekambaram, B., 2002, Prediction of body weight changes based on biometrical measurements in grazing Deccani sheep. *Indian J. Anim. Sci.*, **72**(7) : 607-608.
- Ramesh Gupta, B. and Krishna Reddy, K., 1986, Reproductive traits of Mandya and Mandya synthetic ewes. *Indian J. Anim. Sci.*, **56**(7) : 773-778.
- Reddy, A.K., 1980, Studies on certain economic traits in Nellore breed of sheep. M.V.Sc. Thesis, A.P.A.U., Hyderabad.
- Reddy, A.K., Sarma, P.L.N., Datta, O.P. and Krishnamacharyulu, E., 1983, Genetic and phenotypic parameters of monthly body weights and some reproductive traits in Nellore sheep. *Indian J. Anim. Sci.*, **53** : 27-30.
- Reddy, K.K. and Rai, A.V., 1987a, Factors influencing pre-weaning body weights of Mandya and Nellore and their halfbreds with Dorset and Suffolk. *Indian J. Anim. Genet. Breed.*, **9** : 18-21.
- Reddy, K.K. and Rai, A.V., 1987b, Factors affecting post weaning (6-12 months) body weights of Mandya. Nellore and their half-breds with Dorset Horn and Suffolk breeds. *Indian Vet. J.*, **64** : 677-682.
- Sahani, M.S., Bapna, D.L. and Arora, A.L., 1993, Factors influencing different body weights in Karakul sheep under north west arid region. *Livestock Advisor*, **18**(3) : 11-16.
- Shah, R.R. and Patel, M.M., 1989, Growth and wool traits up to six months of age in Patanwadi and its crosses. *Indian J. Anim. Genet. Breed.*, **11** : 20-24.
- Sharma, B.S., Yadav, S.B.S., Barhat, N.K. and Taneja, A.D., 1991a, Factors influencing body weight and growth up to yearlings in Magra and its crosses with Soviet Merino and Corriedale sheep. *Indian J. Anim. Sci.*, **61** : 555-557.
- Sharma, M.K., Sharma, N.K., Singh, V.K. and Beniwal, B.K., 2003a, Genetic evaluation of Nali and Marwari sheep in arid zone of Rajasthan : Body weights. *Indian J. Small Rumin.*, **9**(1) : 65-68.

- Sharma, R.C., Arora, A.L., Mishra, A.K. and Sushil Kumar, 2003b, Production performance of Malpura sheep in an organized farm in Rajasthan. *Indian J. Small Rumin.*, **9**(2) : 119-121.
- Sheikh, N.A., Dhillon, J.S. and Parmar, O.S., 1986, Genetic evaluation of a flock of Kashmir Merino sheep. 1. Body weights. *Indian J. Anim. Sci.*, **56** : 244-247.
- Siddalinga Murthy, H.K., 2001, Evaluation of Bandur sheep in Mandy District of Karnataka for economic traits. M.V.Sc. Thesis submitted to UAS, Bangalore.
- Singh, V.K. and Mathur, P.B., 1971, Studies on body measurements indicating mutton production. *Indian Vet. J.*, **48** : 829-834.
- Singh, B.B., and Singh, M.R., 1974, Relative importance of body measurements for body weight and wool yield of Bikaneri lambs. *Indian J. Anim. Hlth.*, **13** : 37-40.
- Singh, B. and Prakash, B., 1986, Factors affecting the body weights in Gaddi sheep and its crosses with Rambouillet and Russian Merino. *Indian Vet. J.*, **63** : 143-146.
- Singh, B., Bhat, P.N., Mohan, M. and Chopra, S.C., 1987, Factors affecting preweaning and post weaning body weights in native breeds of sheep and their crosses with exotic breeds. *Indian J. Anim. Genet. Breed.*, **9** : 26-28.
- Singh, B.P., Singh, B.B. and Singh, M.R., 1972, Relationship of wool yield with age, weight and body measurements of Bikaneri sheep. *Indian J. Anim. Sci.*, **42** : 218-220.
- Singh, G. and Singh, V.K., 1984, Effect of crossing and intercrossing on growth in Coimbatore and its crosses with Corriedale sheep. *Indian Vet. J.*, **61** : 1054-1060.

- Singh, N.K. and Singh, S.K., 1997, Genetic and phenotypic parameters of body weights, average daily gains and first shearing wool yield in Muzaffarnagari sheep. *Small Rumin. Res.*, **26** : 21-29.
- Singh, V.K., Mishra, A.K. and Sushil Kumar, 2005, Genetic improvement of sheep for wool and mutton production in India : A review. *Indian J. Anim. Sci.*, **75**(3) : 356-64.
- Snedecor, G.W. and Cochran, W.G., 1989, Statistical Methods, 8<sup>th</sup> Edition, Iowa State University Press, Ames, Iowa (USA).
- Sreenivasu, B., Narasimha Rao, G., Ramesh Gupta, B. and Satyanarayana, A., 2003, A study on body weights and biometrical measurements of Deccani sheep under field conditions. *Indian J. Anim. Res.*, **37**(2) : 133-135.
- Sushil Kumar, Sharma, R.C., Mishra, A.K. and Arora, A.L., 2003, Production performance of sheep and certain management practices in farmers flocks of south east Rajasthan. *Indian J. Small Rumin.*, **9**(2) : 103-105.
- Swain, N., Gopikrishna, G., Gour, D. and Sanyal, P.K., 2004, A long-term study on the production performance of Bharat Merino sheep in a sub-temperate region of Tamil Nadu. *Indian Vet. J.*, **81** : 679-682.
- Tailor, S.P. and Yadav, C.M., 2011, Growth performance of pre- and post-weaning Sonadi lambs and adults in the native tract. *Indian Journal of Small Ruminants (The)*, **17**(2) : 221-224.
- Tailor, S.P., Lokesh Gupta and Nagda, R.K., 2007, Productive and reproductive performance of Sonadi sheep in their native tract. *Indian J. Small Rumin.*, **13**(1) : 51-54.
- Tailor, S.P., Nagda, R.K. and Lokesh Gupta, 2006, Characterization and evaluation of Sonadi sheep in its native tract. *Indian Journal of Small Ruminants*, **12**(2) : 206-211.
- Taneja, A.D., Yadav, S.B.S., Sharma, B.S. and Pant, K.P., 1993, Body dimensions of Magra sheep in farmers flock. *Indian J. Anim. Sci.*, **63**(6) : 681-683.

- Thiruvankadan, A.K., Karunanithi, K., Babu, R.N. and Arunachalam, K., 2008, Comparative performance of Mecheri lambs under different management systems. *Indian J. Small Rumin.*, **14** : 84-88.
- Tomar, A.K.S., Mehta, B.S. and Gurmej Singh, 2000, Genetic and non-genetic factors affecting growth in Bharat Merino sheep. *Indian J. Anim. Sci.*, **70** : 647-648.
- Turner, H.N., Hayman, R.H., Rickes, J.H., Roberts, N.F. and Wilson, L.T., 1953, Physical definition of sheep and their fleece for breeding and husbandry studies. Division of Animal Health and Production, CSIRO, Melbourne, Australia.
- Ulaganathan, V., Karunanidhi, K. and Krishnan, A.R., 1989, Comparative performance of Dorset quarterbreeds and Mecheri breed of sheep. *Indian J. Anim. Sci.*, **59** : 1167-1170.
- Urala, K.A.R., 1977, Genetic studies on body weights in Bannur sheep. M.V.Sc. Thesis submitted to the University of Agricultural Sciences, Bangalore.
- Vij, P.K., Tantia, M.S. and Nivsarkar, A.E., 1997, Characteristics of Bonpala Sheep. *Anim. Gene. Res. Inform.*, **22** : 15-18.
- Vimal Selvaraj, Ramesh Kumar, T., Senthil Nathan, R., Meenakshisundaram, S. and Gajendran, K., 2002, Prediction of body weight from body measurements in Madras Red sheep. *Indian J. Anim. Sci.*, **72**(1) : 180-181.
- Wadyal, S.S. and Balaine, D.S., 1971, Studies on physical measurements body weight and fleece weight in Nali and Lohi sheep. *Indian J. Anim. Sci.*, **41** : 671-674.
- Waghmode, P.S., Sawane, M.P., Pawar, V.D. and Ingawale, M.V., 2008, Effect of non-genetic factors on growth performance of Madgyal sheep. *Indian J. Small Rumin.*, **14** : 127-130.
- Warris, P.D. and Edwards, J.W., 1995, Estimating the live weight of sheep from chest girth measurements. *Vet. Rec.*, **137** : 123-124.



# **ABSTRACT**

## VIII. ABSTRACT

The present study was undertaken, to compile information on morphological traits of Bandur sheep in the home tract, to assess performance of growth and reproductive traits, to predict body weight at six and twelve months of age based on body measurements and to estimate heritabilities of body weights. Data were collected from 3210 sheep from selected taluks of Mandya, Mysore, Bangalore (Rural) and Kolar districts of Karnataka. The breed morphological characters noted were, coat colour is predominantly white colour with light brown face, convex fore head, wattles were absent in majority of sheep, with medium length tail, ears were pendulous while horns were absent in Bandur sheep . The overall means obtained for body weight at three , six, nine, twelve month and adults was  $4.79 \pm 0.09$ ,  $11.40 \pm 0.13$  ,  $15.86 \pm 0.07$  ,  $26.13 \pm 0.11$  and  $28.28 \pm 0.04$  kg respectively. The overall mean chest girth of the sheep at 3,6,9,12 month and adult age groups were  $45.21 \pm 1.22$ ,  $56.89 \pm 0.40$ ,  $71.40 \pm 0.25$ ,  $77.65 \pm 0.18$  and  $75.98 \pm 0.16$  cm respectively. The mean body length of pooled data for 3, 6, 9, 12 month and adult sheep were  $41.58 \pm 0.49$ ,  $51.20 \pm 0.77$ ,  $53.18 \pm 0.24$ ,  $61.74 \pm 0.95$  and  $63.64 \pm 0.13$  cm respectively. The mean height at wither for pooled data in the five age groups were  $42.66 \pm 0.54$ ,  $45.9 \pm 0.47$ ,  $48.52 \pm 0.08$ ,  $52.20 \pm 0.11$  and  $53.90 \pm 0.10$  cm respectively. The overall mean age at first lambing was  $642.14 \pm 2.95$  days and the overall lambing interval was  $249.66 \pm 0.56$  days. The heritability estimates of body weight at three, six , nine and twelve months were  $0.21 \pm 0.09$ ,  $0.82 \pm 0.23$ ,  $0.19 \pm 0.07$  and  $0.72 \pm 0.06$ , respectively. The correlations of body weights at six and twelve months were positive and highly significant ( $P \leq 0.01$ ). In the present study, contribution of CG in all the five equations was significant ( $P \leq 0.05$ ) with higher  $R^2$  value