1. INTRODUCTION

Livestock sector plays an important role in socio-economic development of the country. The contribution of this sector in form of milk, meat, egg and wool, to the national economy in terms of Gross Domestic Product (GDP) was 4.11 % during 2012-13. Goat substantially contributes to the rural economy and provide livelihood to the poor sections and supplement their food with nutritious milk and meat. Total milk production of the country was 132.4 million tonnes, to this Rajasthan contributed 10.56 % in 2012-2013. (Basic Animal Husbandry Statistics, 2013). The nutritional value of goat meat is high, since it has 10% more leaner than beef carcasses and 19% more leaner than lamb carcasses, which makes it more attractive product for the health of consumers (Amoah and Gelaye, 2003).

India is a rich repository of goat genetic resources in the form of 23 well defined breeds (NBAGR, 2013). The total goat population of country was 135.17 million, which constituted 26.40 % of total livestock population (Livestock census, 2012). Rajasthan ranks first in the country contribute 16.03 % of total goat population. Among various goat genotypes available, the Sirohi is one of the principal and renowned breed of goats in Rajasthan which has derived its name from Sirohi district of Rajasthan with other variants such as Deogarhi or Parbatsari and Madariya (Yadav and Khada 2009). Animals of this breed are found in arid and semi-arid region along with most part of Arawali hills and outlying districts in central and southern Rajasthan (Udaipur, Sirohi, Pali, Rajasamand, Dungarpur, Banswara, Chittorgarh, Bundi, Bhilwara, Swai-Madhopur, Kota, Ajmer, etc.) and neighboring districts of Uttar Pradesh (Agra, Mathura and Ettawah) and north part of Gujarat state (Palanpur and adjoining area). This breed has proved to be an excellent goat breed with respect to disease resistance, adaptability in dry and hot climates, and ability to perform under poor quality range conditions.

The source of income from this breed depends mainly upon meat and milk production. For increasing meat yield from live weight of this breed, genetic improvement is required. Selective breeding is targeted to attain higher growth rate and carcass weight in animals (Bhusan 2012). Growth traits are affected by various genetic and non-genetic factors like sire, sex, season and years. Studies conducted on organized farms (Yadav *et al.* 2013 in Kutchi breed and Singh *et al.* 2013 in Jamunapari breed) as well as field condition (Sharma *et al.* 2010 and Sharma and Pathodia, 2007 in Sirohi goats) have shown varying level of significance regarding various genetic and non-genetic factors.

Production traits are affected by various non-genetic factors like sex, season, year and type of birth, obscuring recognition of genetic potential (Kumar *et al.,* 2007). Milk production of does also affect early growth and survival of their kids. The information available in the literature with regard to effect of genetic and non-genetic factors affecting production traits under field condition (Tyagi *et al.* 2013 in Surti goats and Pathodiya *et al.* 2010 in Sirohi goats) and organized farms (Singh and Ramachandran, 2007 in Sirohi goats and Swami *et al.* 2005 in Sirohi and its crosses with Beetal) suggested their consideration in formulating strategies for genetic improvement of goats.

Reproduction efficiency is always considered to be the most vital factor to increase productivity under given environmental conditions. The genetic merit of a doe depends not only on milk production but also on several reproductive traits namely, age at sexual maturity, age at first conception, age at first kidding and kidding interval (Maroof *et al.* 2007). The appropriate replacement of breeding males and females in a flock depend on the sex ratio (Soundrarajan and Sivakumar 2006). Information is available about genetic and non-genetic factors affecting reproduction performance of various Indian goat breeds under field conditions (Kumar *et al.* 2012 and Pathodiya *et*

al. 2008 in Sirohi goats) and organized farms (Singh *et al.* 2000 in Black Bengal its crosses with Beetal goats). It necessitate adjustment of performance records for classifiable non-genetic sources of variation for obtaining precise estimates of genetic parameters and breeding values so that breeding animals with the potential genetic merit can be identified and selected for further genetic improvement.

The body weight of a goat is important for a number of reasons, related to breeding (selection), feeding and health care. However this fundamental knowledge is often unavailable to those working with goats in the small scale-farming sector, due to unavailability of weighing scales. Hence, farmers have to rely on questionable estimates of the body weight of their goats, leading to inaccuracies in decision-making and husbandry. The method of weighing animals without scales is to obtain a regression formula of body weight on a certain number of body characteristics, which can be measured easily. The method of estimating weight of animals without scales is to regress body weight on a certain other body characteristics. Body measurements have been used to predict body weight by several authors in many breeds of Indian goats (Thiruvenkadan, 2005; Sharma and Das, 1995; Das *et al.*, 1990).

Hence the following study was undertaken to determine the best fitted regression model for prediction of live weight of Sirohi goats and the effects of various genetic and non-genetic factors on the body weight, morphometric traits at various stages, production and reproduction traits of Sirohi goat along with genetic and phenotypic associations among these traits with heritability estimates to develop suitable selection and breeding strategies, under north-western agro-climatic conditions of Rajasthan under field conditions with following objectives:

1. To study the growth, production and reproduction performance of Sirohi goats under field condition.
2. To study the various genetic and non-genetic factors affecting growth, production and reproductive performance of Sirohi goats.
3. To estimate the genetic parameters like heritability, phenotypic and genetic correlations of various goat traits under study.
4. To develop equations for predicting body weights from body measurements of kids.

2. REVIEW OF LITURATURE

The literature available on growth, production and reproduction traits has been reviewed under the following classes:

2.1 Body weight at different ages (*viz.* birth, 3 months, 6 months, 9 months and 12 months).
2.2 Genetic and non-genetic factors affecting the body weight at different ages.
2.3 Genetic and phenotypic parameters for body weight at different ages.
2.4 Morphometric traits at different ages (*viz.* birth, 3 months, 6 months, 9 months and 12 months).
2.5 Genetic and non-genetic factors affecting morphometric traits at different ages.
2.6 Genetic and phenotypic parameters for morphometric traits at different ages.
2.7 Production performance and factors affecting it.
2.8 Reproduction performance and factors affecting it.
2.9 Prediction equation for body weight from body measurements.

2.1 Body weight at different ages:

The least-squares means of body weights of various breeds of goats reported by different workers have been presented in Table 2.1.

In Sirohi goats overall birth weight ranged from 2.10 ± 0.06 kg (Bhakar, 2014) to 3.12 ± 0.05 kg (Gowane *et al.,* 2011b), 3 months body weight ranged from 10.71 ± 0.33 kg (Tomar *et al.,* 2004) to 13.29 ± 0.42 Kg (Bhakar, 2014), 6 months body weight ranged from 15.24 ± 0.28 kg (Sharma and Pathodiya, 2007) to 19.29 ± 0.22 kg (Mehta *et al.,* 1997), 9 months body weight ranged from 18.33 ± 0.33 kg (Sharma and Pathodiya, 2007) to 22.02±0.10 kg (Gowane *et al.,* 2011a) and 12 months body weight ranged from 21.94 ± 0.35 kg (Sharma and Pathodiya, 2007) to 25.80 ± 0.12 kg (Gowane *et al.,* 2011a).

Across the different breeds of goats in India, the overall birth weight ranged from 0.98±0.01 kg in Black Bengal goats (Husain *et al*., 1996) to 3.38 ±0.06 kg in Beetal goats (Afzal *et al.,* 2004), 3 months body weight ranged from 4.64±0.58 kg in Assam local breed of goats (Sarmah *et al.,* 2011) to 14.47±0.57 Kg in Sangamneri breed of goats (Verma *et al.,* 2010), 6 months body weight ranged from 6.99±.40 kg in Assam local breed of goats (Sarmah *et al.,* 2011) to 20.26±0.83 kg in Sangamneri goats (Verma *et al.,* 2010), 9 months body weight ranged from 10.67±0.36 kg in Black Bengal goats (Husain *et al.,* 1996) to 22.02±0.10 kg in Sirohi goats (Gowane *et al.,* 2011a) and 12 months body weight ranged from 10.54±0.64 kg in Assam local (Sarmah *et al.,* 2011) to 27.28±0.38 kg in Beetal goats (Alam *et al.,* 2007).

Table 2.1: Estimates of least squares means (kg) of body weights of kids up to yearling reported by different workers

Breed/ Genetic group	Birth	3 months	6 months	9 months	12 months	References
Sirohi	2.88±0.03	12.58±0.17	19.29±0.22	22.01±0.33	25.58±0.47	Mehta *et al.* (1997)
	2.14±0.02	10.94±0.10	15.82±0.14	19.42±0.24	23.73±0. 25	Pathodiya *et al.* (2003)
	2.18±0.02	11.23±0.12	15.76±0.15	18.65±0.37	22.09±0. 18	Pathodiya (2004)
	2.84±0.07	10.71±0.33	15.33±0.50	-	-	Tomar *et al.* (2004)
	2.16±0.05	10.84±0.23	15.24±0.28	18.33±0.40	21.94±0. 35	Sharma and Pathodiya (2007)
	2.35±0.04	12.80±0.19	16.31±0.21	19.34±0.25	23.27±0. 36	Meel *et al.* (2010)
	2.16±0.05	10.84±0.23	-	-	-	Sharma *et al. (*2010)
	2.89±0.01	11.37±0.09	16.35±0.14	20.22±0.18	24.45±0. 22	Arora *et al.* (2011)
	3.11±0.01	12.93±0.06	18.36±0.09	22.02±0.10	25.80±0. 12	Gowane *et al.* (2011a)
	3.12±0.05	11.45±0.22	17.49±0.41	-	-	Gowane *et al.* (2011b)
	2.10 ±0.06	13.29 ±0.428	16.94 ±0.650	20.00 ±0.868	24.87 ±1.105	Bhakar (2014)
Berari	2.43± 0.04	10.60 ±0.67	15.08 ±0.30	--	21.14 ±0.39	Kharkar *et al.* (2014)
Ganjam	2.25±0.01	6.80±0.03	9.95±0.04	12.27±0.06	14. 47±0.06	Rao *et al.* (2007)
Barbari	1.88 ± 0.57	6.93 ± 0.30	-	-	-	Bharathidhasan *et al.* (2009)
Kutchi	3.18±0.24	11.34±0.46	17.96±0.62	-	26.28±1.23	Kumar *et al.* (2006)
	2.94	12.44	17.64	-	-	Kumar *et al.* (2007)
	3.19±0.02	9.59±0.13	15.83±0.15	19.31±0.16	21.84±0.15	Yadav *et al*. (2013)
Tellicherry	2.27±0.08	9.303±0.19	13.137±0.02	-	-	Kumar *et al.* (2005)
	2.2±0.1	7.2±0.3	10.5±0.4	13.8±0.5	16.9±0.6	Thiruvenkadan *et al.* (2008)
	2.17±0.03	8.71±0.15	12.05±0.19	15.09±0.26	18.78±0.44	Thiruvenkadan *et al.* (2009)

Tellicherry x Salem black	2.1±0.1	7.3±0.4	10.0±0.4	11.7±0.4	15.3±0.4	Thiruvenkadan *et al.* (2008)
Osmanabadi	-	-	10.57±0.09	12.93±0.10	15.82±0.23	Rathod *et al.* (2011)
	1.85±0.02	6.99±0.03	14.15±0.03	-	20.18±1.03	Birari *et al.* (2012)
Malabari	-	8.83±0.83	13.78±0.83	-	23.44±1.18	Verma *et al.* (2009)
	-	8.28±0.16	15.99±0.33	-	-	Alex and Raghavan (2012)
Black Bengal	0.98±0.01	4.87±0.I7	8.39±0.28	10.67±0. 36	12.61±0.20	Husain *et al.* (1996)
	1.75±0.07	7.64±0.28	11.39±0.40	-	16.54±0.55	Singh *et al.* (2002)
	1.29±0.03	5.16±0.08	7.52±0.15	-	13.08±0.26	Kumar *et al.* (2011)
	1.29 ± 0.04	-	-	-	-	Kumar *et al.* (2012)
Beetal x Black Bengal	1.85±0.07	7.86±0.30	12.41±0.43	-	18.65±0.58	Singh *et al.* (2002)
Black Bengal x Beetal	2.28±0.06	7.17±0.28	12.67±0.40	-	18.23±0.54	
Beetal	2.54±0.04	8.56±0.18	12.87±0.23	-	18.98±0.34	Singh *et al.* (2002)
	3.38 ±0.06	-	-	-	-	Afzal *et al.* (2004)
	2.98±0.52	13.64±0.11	19.40±0.44	-	27.28±0.38	Alam *et al.* (2007)
Jakhrana	2.521	8.558	-	-	-	Bhusan and Rai (2007)
	2.66±0.06	8.82±0.20	11.70±0.28	15.54±0.59	21.89±0.7 1	Mandal *et al.* (2010)
	2.59±0.09	09.23±0.38	13.49±1.04	16.52±0.66	22.63±0. 87	Bhusan (2012)

Marwari	3.05±0.05	11.35±0.17	14.94±0.21	19.98±0.22	23.19±0.18	Rai *et al.* (2004)
	-	8.95±1.39	10.73±0.48	-	14.34±0.61	Barhat (2005)
	2.42±0.06	10.17±0.32	14.68±0.49	17.84±0.59	20.92±0. 66	Patel *et al.* (2005)
Jamunapari	2.87±0.20	12.52±1.06	18.80±1.92	20.92±1 .44	25.05±1.58	Patel *et al.* (2005)
	3.14±0.02	10.52±0.07	14.95±0.10	20.57±0.13	25.68±0. 15	Singh *et al.* (2009)
	3.17±0.01	10.60±0.05	14.62±0.06	19.87±0.09	24.61±0. 11	Singh *et al.* (2013)
Marwari x Jamunapari	2.89±0.10	10.21±0.47	14.99±0.68	19.28±0.68	23.60±0. 77	Patel *et al.* (2005)
Surti	1.838±0.02	10.083±0.12	17.184±0.19	20.742±0. 31	23.388±0.64	Tyagi *et al.* (2013)
Sangamneri	-	14.47±0.57	20.26±0.83	-	-	Verma *et al.* (2010)
	-	9.02±0.08	14.09±0.10	17.77±0.13	-	Jagdale *et al.* (2012)
	-	9.18±0.05	14.05±0.12	19.10±0.26	22.38±0.36	Patil *et al.* (2013)
Assam local	1.05 1.01	5.29 1.30	9.53 0.17	11.69 0.57	12.45 0.39	Gohain *et al.* (2014)
	1.16±0.07	4.64±0.58	6.99±.40	-	10.54±0.64	Sarmah *et al.* (2011)
Beetal x Assam local	1.45±0.06	6.36±0.47	9.70±.35	-	14.40±0.54	
Common African	2.7±0.10	8.7±0.10	13.2±0.10	-	-	Mourad and Anous (1998)
Angora	2.26±0.01	-	-	-	20.4±0.18	Liu *et al.* (2005)
Boer x Kanni	2.44±0.17	-	-	-	-	Sivakumar *et al.* (2005)
Markhoz	2.48±0.04	13.78±0.41	16.61±0.45	21.20±0.46	27.03±0.64	Rashidi *et al.* (2008)

Red Sokoto	1.80±0.03	7.60±0.02	10.60±0.02	12.80±0.02	-	Akpa *et al.* (2009)
Mahabubnagar	2.13 ± 0.02	8.70 ± 0.08,	12.23 ± 0.10	15.01±0.10	17.89 ± 0.13	Ekambaram *et al.* (2010)
Egyptian	1.94±0.00	10.80±0.03	15.40±0.04	-	-	Aboul-Naga *et al.* (2012)
Raeini	2.05±0.02	10.09±0.03	14.38±0.20	17.13±0.60	17.99±0.30	Mohammadi *et al.* (2012)
Teddy	1.66±.003	9.59±0.01	11.70±0.02	16.69±0.02	21.03±0.03	Kuthu *et al.* (2013)

2.2 Genetic and non-genetic factors affecting the body weight at different ages

The body weights are the most important characters for efficient meat production. The body weight at birth gives the first measurable trait which reflects the prenatal growth, at subsequent ages determines the postnatal growth and survivability. Body weight at different stages of life provides suitable selection criteria. Increase in productivity can be achieved by providing proper environment in terms of feeding, management and disease control, which have immediate and considerable effects but are temporary. Secondly improving the genotypes of animals by proper selection and breeding system can attain the improvement permanently. Before planning and implementing a breeding strategy for improving the breed, it is necessary to evaluate the factors affecting body weights.

Genetic factors affecting the body weights:

2.2.1 Sire:

Sires leave more numbers of progeny than dam thus sire has a greater impact on the flock for which it is said that sire is “half of the flock”. Effects of sire on body weights as reported by various workers in different breeds of goats has been presented in Table 2.2

Significant (P≤ 0.05) effect of sire from birth to 12 months of age on body weight reported by Roy *et al.* (1997) in Jamunapari goats, highly significant (P≤ 0.01) effect of sire from birth to 9 months and significant (P≤ 0.05) effect on 12 months of age on body weight reported by Yadav *et al.* (2003) in Kutchi goats. However, non-significant effect of sire on body weights at birth, 9 and 12 months of age in Jamunapari goats (Kumar *et al*., 1992), at 12 months of age in Marwari goats (Rai *et al.,* 2004) and in Kutchi goats (Yadav *et al.,* 2013) also has been observed.

In Sirohi goats Pathodiya *et al.* (2004) estimated significant (P≤ 0.05) effect on birth weight, Sharma (2005) and Bhakar (2014) reported highly significant (P≤ 0.01) effect on body weights from birth to 12 months of age.

Table 2.2: Reports showing effect of the sire on body weight of kids at different stages

Breed/ Genetic group	Body weight at					References
	Birth	3 Months	6 Months	9 Months	12 Months	
Sirohi	*	-	-	-	-	Pathodiya *et al.* (2004)
	**	**	**	**	**	Sharma (2005)
	**	**	**	**	**	Bhakar (2014)
Malabari	-	*	-	-	-	Mukundan*et al.* (1983)
Jamunapari	NS	*	*	NS	NS	Kumar *et al.* (1992)
	*	*	*	*	*	Roy *et al.* (1997)
Chegu	*	-	-	-	-	Karna *et al.* (2001)
Kutchi	**	**	**	**	*	Yadav *et al.* (2003)
	*	*	*	*	NS	Yadav *et al.* (2013)
Beetal	*	-	-	-	-	Afzal *et al.* (2004)
Marwari	*	*	*	*	NS	Rai *et al.* (2004)
Sudan	*	*	*	-	-	Yousif *et al.* (2011)

Note: ** = Highly significant (P≤0.01), *= Significant (P≤0.05), NS= Non-significant

Non-genetic factors affecting the body weights:

2.2.2 Cluster/ Location

An effect of cluster/location on body weights as reported by various workers in different breeds of goats has been presented in Table 2.3.

Significant (P≤ 0.05) or highly significant (P≤0.01) effect of cluster/ location on body weights except Patil *et al.* (2013) at 3, 9 and 12 months of age in Sangamneri goats and Kharkar *et al*. (2014) at birth and 3 months of age in Berari goats who were reported non-significant effect of cluster on body weights.

In Sirohi goats, Joshi (1991) reported significant effect (P≤0.05) of location on birth weight, 3 and 6 months, Sharma (1994) on birth, 3, 6 and 12 months weights, Gokhale *et al.* (1996) on birth, 3 and 6 months weights. While Sharma *et al.* (2010) reported significant effect (P≤0.05) of cluster on birth weight and highly significant effect (P≤0.01) on 3 months weight. Bhakar (2014) also reported highly significant effect of cluster form birth to 12 months of age.

2.2.3 Year of birth

The effect of year of birth occur on body weight may be due to changes in pasture, fluctuations in ambient temperature, rainfall and humidity year-to-year. Management and health condition of the flock over the years are also important for proper growth of kids. The effect of year of birth on body weights reported by various workers has been reviewed in Table 2.4.

In Sirohi goats Kuralker *et al.* (2002) at birth, 3 and 6 months of ages and Pathodiya (2004) at 9 months of age recorded significant effect (P≤0.05) of year of birth on body weight. While highly significant effect (P≤0.01) of year of birth was reported by Pathodiya *et al.* (2003) on birth, 3, 6 and 9 months body weights, Pathodiya (2004) on birth, 3, 6 and 12 months body weights, Meel *et al.* (2010) on birth, 3, 6, 9 and

12 months body weights and Sharma *et al.* (2010) on birth and 3 months body weights. Bhakar (2014) also reported highly significant effect of year of birth form birth to 12 months of age. On the contrary Pathodiya *et al.* (2003) was found year of birth as a non-significant effect on body weight at 12 months of age.

2.2.4 Season of birth

The seasonal variation due to availability of good quality pastures to the pregnant does and growing kids, ambient temperature, humidity etc. has considerable influence on growth traits at different ages. The effect of season of birth on kid's body weight at different ages as observed by various researchers has been presented in Table 2.5.

In Sirohi goats highly significant (P≤0.01) effect of season of birth was observed by Pathodiya *et al.* (2003) on birth, 3 and 6 months body weights, Pathodiya (2004) on birth and 3 months body weights, Meel *et al.* (2010) on birth, 3, 6 and 9 months body weights, Sharma *et al.* (2010) on 3 months body weight and Arora *et al.* (2011) on birth, 3, 6, 9 and 12 months body weights. On the other hand Pathodiya *et al.* (2003) on 9 and 12 months body weights, Pathodiya (2004) on 6, 9 and 12 months body weights, Meel *et al.* (2010) on 12 months weight and Sharma *et al.* (2010) on birth weight estimated season of birth as a non-significant effect in Sirohi goats.

Table 2.3: Reports showing effect of the cluster/ location on body weight of kids at different stages

Breed/ Genetic group	Body weight at					References
	Birth	3 Months	6 Months	9 Months	12 Months	
Sirohi	*	*	*	-	-	Joshi(1991)
	*	*	*	-	*	Sharma (1994)
	*	*	*	-	-	Gokhale *et al.* (1996)
	*	**	-	-	-	Sharma *et al.* (2010)
	**	**	**	**	**	Bhakar (2014)
Berari	NS	NS	-	-	-	Kharkar *et al*. (2014)
Beetal	*	-	-	-	-	Afzal *et al.* (2004)
Malabari	-	*	*	-	-	Alex and Raghavan (2012)
Osmanabadi	**	**	**	-	**	Birari *et al.* (2012)
Sangamneri	-	**	**	**	-	Jagdale *et al.* (2012)
	-	NS	*	NS	NS	Patil *et al.* (2013)
Surti	*	*	*	*	*	Tyagi *et al.* (2013)
Teddy	**	**	**	**	**	Kuthu *et al.* (2013)

Note: ** = Highly significant (P≤0.01), *= Significant (P≤0.05), NS= Non-significant

Table 2.4: Reports showing effect of the year of birth on body weight of kids at different stages

Breed/ Genetic group	Body weight at					References
	Birth	3 Months	6 Months	9 Months	12 Months	
Sirohi	*	*	*	-	-	Kuralker *et al.* (2002)
	**	**	**	**	NS	Pathodiya *et al.* (2003)
	**	**	**	*	**	Pathodiya (2004)
	**	**	**	**	**	Meel *et al.* (2010)
	**	**	-	-	-	Sharma *et al.* (2010)
	**	**	**	**	**	Bhakar (2014)
Jamunapari	*	*	*	*	*	Roy *et al.* (1989)
	*	*	NS	*	-	Kumar *et al.* (1992)
	*	**	**	**	**	Rout *et al.* (2002)
Barbari	**	*	**	**	**	Singh and Rout (2001)
Beetal	*	-	-	-	-	Afzal *et al.* (2004)
Marwari	*	*	NS	NS	NS	Rai *et al.* (2004)

Jakhrana	NS	*	*	*	*	Mandal *et al.* (2010)
	**	**	*	**	NS	Bhusan (2012)
Black Bengal	NS	NS	*	-	NS	Kumar *et al.* (2011)
Sangamneri	-	NS	NS	*	-	Jagdale *et al.* (2012)
	-	**	**	**	NS	Patil *et al.* (2013)
Malabari	-	*	*	-	-	Alex and Raghavan (2012)
Kutchi	*	NS	NS	NS	NS	Yadav *et al.* (2003)
	*	*	NS	-	-	Kumar *et al.* (2007)
	*	*	*	*	NS	Yadav *et al.* (2013)
Surti	*	*	*	*	*	Tyagi *et al.* (2013)
Markhoz	**	**	**	**	**	Rashidi *et al.* (2008)
Iraqi local	**	**	**	**	**	Hermiz *et al.* (2009)
Raeini	**	**	**	**	**	Mohammadi *et al.* (2012)

Note: ** = Highly significant (P≤0.01), *= Significant (P≤0.05), NS= Non-significant

Table 2.5: Reports showing effect of the season of birth on body weight of kids at different stages

Breed/ Genetic group	Body weight at					References
	Birth	3 Months	6 Months	9 Months	12 Months	
Sirohi	**	**	**	NS	NS	Pathodiya *et al.* (2003)
	**	**	NS	NS	NS	Pathodiya (2004)
	**	**	**	**	NS	Meel *et al.* (2010)
	NS	**	-	-	-	Sharma *et al.* (2010)
	**	**	**	**	**	Arora *et al.* (2011)
	NS	**	*	**	**	Bhakar (2014)
Berari	NS	*	NS	-	**	Kharkar *et al.* (2014)
Jamunapari	*	NS	*	NS	NS	Roy *et al.* (1989)
	**	**	**	**	**	Singh *et al.* (2009)
Jakhrana	NS	*	-	-	-	Singh and Khan (2002)
	*	*	*	*	*	Mandal *et al.* (2010)
	NS	NS	NS	NS	*	Bhusan (2012)

Tellicherry	**	**	**	-	-	Kumar *et al.* (2005)
	NS	**	NS	**	**	Thiruvenkadan *et al.* (2009)
Marwari	*	NS	NS	NS	NS	Rai *et al.* (2004)
Kutchi	**	**	**	-	-	Kumar *et al.* (2007)
	*	*	*	*	*	Yadav *et al.* (2008)
	*	*	*	*	NS	Yadav *et al.* (2013)
Sikkim local	NS	-	-	-	-	Chandra *et al.* (2009)
Bundelkhandi	*	-	-	-	-	Kumar *et al.* (2010)
Black Bengal	**	*	NS	-	NS	Kumar *et al.* (2011)
	**	-	-	-	-	Kumar *et al.* (2012)
Sangamneri	-	NS	*	NS	-	Jagdale *et al.* (2012)
	-	**	**	NS	NS	Patil *et al.* (2013)
Malabari	-	*	NS	-	-	Alex and Raghavan (2012)
Draa	*	NS	**	-	-	Boujenane and Hazzab (2008)
Teddy	**	**	**	**	NS	Kuthu *et al.* (2013)
Zaraibi	NS	*	**	-	-	Osman *et al.* (2013)

Note: ** = Highly significant (P≤0.01), *= Significant (P≤0.05), NS= Non-significant

2.2.5 Parity of dam

Effect of parity of dam on kid's body weight at various ages as evaluated by different researchers has been reviewed in Table 2.6.

Reports show significant (P≤0.05), highly significant (P≤0.01) and non-significant effect of parity of dam on body weights of kids at birth, 3, 6 and 9 months of age. While body weight at 12 months of age was un-affected by the parity of dam in all reports.

In Sirohi goats highly significant (P≤0.01) effect of parity of dam on body weights at birth, 3 and 6 months of age was observed by Pathodiya *et al.* (2003) and at birth and 3 months of age by Pathodiya (2004). However, non-significant effect of parity of dam on body weight in Sirohi kids was also reported by Joshi (1991) at birth, 3, 6 and 12 months of ages, Pathodiya *et al.* (2003) at 9 and 12 months of ages, Pathodiya (2004) at birth and Pathodiya *et al.* (2004) at 6, 9 and 12 months of ages.

2.2.6 Type of kidding

The reports regarding effects of type of kidding on body weight at different stages is shown in Table 2.7.

In Sirohi breed of goats effect of type of kidding on body weights was reported as significant (P≤0.05) at birth to yearling (Mehta *et al*., 1997) and at 3 months of age (Sharma *et al.,* 2010). On the other hand type of kidding had highly significant (P≤0.01) effect on body weight of Sirohi kids at birth, 3 and 6 months of ages (Tomar *et al.,* 2004), at birth, 3, 6, 9 and 12 months of ages (Meel *et al.,* 2010), at birth (Sharma *et al.,* 2010) and at birth, 3, 6, 9 and 12 months of ages (Arora *et al.,* 2011).

Table 2.6: Reports showing effect of the parity on body weight of kids at different stages

Breed/ Genetic group	Body weight at					References
	Birth	3 Months	6 Months	9 Months	12 Months	
Sirohi	NS	NS	NS	-	NS	Joshi (1991)
	**	**	**	NS	NS	Pathodiya *et al.* (2003)
	NS	-	-	-	-	Pathodiya *et al.* (2004)
	**	**	NS	NS	NS	Pathodiya (2004)
	NS	NS	**	NS	*	Bhakar (2014)
Tellicherry	NS	NS	NS	-	-	Kumar *et al.* (2005)
	NS	**	**	*	NS	Thiruvenkadan *et al.* (2009)
Jakhrana	*	*	NS	NS	NS	Mandal *et al.* (2010)
Black Bengal	*	-	-	-	-	Kumar *et al.* (2012)
Sahel	**	-	-	-	-	Zahraddeen *et al.* (2007)
Red Skoto	*	*	**	*	-	Alphonsus *et al.* (2010)
Abergele	**	**	*	-	NS	Deribe and Taye (2013)

Note: ** = Highly significant (P≤0.01), *= Significant (P≤0.05), NS= Non-significant

Table 2.7: Reports showing effect of the type of kidding on body weight of kids at different stages

Breed/ Genetic group	Body weight at					References
	Birth	3 Months	6 Months	9 Months	12 Months	
Sirohi	*	*	*	*	*	Mehta *et al.* (1997)
	**	**	**	-	-	Tomar *et al.* (2004)
	**	**	**	**	**	Meel *et al.* (2010)
	**	*	-	-	-	Sharma *et al.* (2010)
	**	**	**	**	**	Arora *et al.* (2011)
	**	**	**	**	**	Bhakar (2014)
Berari	*	NS	NS	-	NS	Kharkar *et al.* (2014)
Beetal	*	-	-	-	-	Afjal *et al.* (2004)
Marwari	*	*	*	NS	NS	Rai *et al.* (2004)
Tellicherry	NS	NS	**	-	-	Kumar *et al.* (2005)
	**	**	**	**	**	Thiruvenkadan *et al.* (2009)
Kutchi	**	**	**	-	-	Kumar *et al.* (2007)
	*	*	NS	NS	NS	Yadav *et al.* (2008)
	*	*	*	*	NS	Yadav *et al.* (2013)
Jamunapari	**	**	**	**	**	Rout *et al.* (2002)
	**	**	**	**	**	Singh *et al.* (2009)
Sikkim local	*	-	-	-	-	Chandra *et al.* (2009)
Mahabubnagar	*	*	*	*	*	Ekambaram *et al.* (2010)
Jakhrana	*	NS	NS	NS	NS	Mandal *et al.* (2010)
	*	NS	*	NS	NS	Bhusan (2012)
Black Bengal	*	*	*	-	*	Kumar *et al.* (2011)
	*	-	-	-	-	Kumar *et al.* (2012)
Malabari	-	*	NS	-	-	Alex and Raghavan (2012)
Ettawah grade	**	**	-	-	-	Sodiq (2012)
Angora	**	-	-	-	**	Liu *et al.* (2005)
Markhoz	**	**	**	**	**	Rashidi *et al.* (2008)

Note: ** = Highly significant (P≤0.01), *= Significant (P≤0.05), NS= Non-significant

2.2.7 Sex of kid

Sex hormones that are released from gonads influence the animal's physiological system and are responsible for differences in body weights in different sexes. The females have slower growth rate than males because of early maturing body and reach a smaller mature size due to effect of estrogen, which restrict the growth of long bones. Castration of male kids results in increased growth rate resulting in higher body weight as compared to females. Various workers have reported the effect of sex of kid and their observations and results are summarized in Table 2.8.

In Sirohi goats significant (P≤0.05) effect of sex of kid on body weights at birth to yearling has been observed by Mehta *et al.* (1997). On the other hand highly significant (P≤0.01) effect was estimated by Meel *et al.* (2010) on birth to yearling weights, Sharma *et al.* (2010) on birth weight and Arora *et al.* (2011) on birth, 3, 6, 9 and 12 months weights. On the contrary non-significant effect of sex of kid on body weights of Sirohi kids also reported by Pathodiya *et al.* (2003) at 6, 9 and 12 months of age and Sharma *et al.* (2010) at 3 months of age.

2.2.8 Dam's weight at kidding

The favorable effect of dam's weight at kidding on body weights of kids may be due to better prenatal environment provided to foetus for growth and development, more secretion of milk by dam and mothering ability of dam. Effect of dam's weight at kidding on birth weight and subsequent body weights of kids were reported by various workers and is summarized in Table 2.9.

In Sirohi goats significant (P≤0.05) effect of dam's weight at kidding on body weights of kids was recorded by Mehta *et al.* (1997) at birth to yearling and Tomar *et al.* (2004) at birth. While highly significant (P≤0.01) effect was observed by Arora *et al.* (2011) on birth to yearling weights. On the contrary Sharma *et al.* (2010) observed this as non-significant effect on 3 months body weight in Sirohi goats.

Table 2.8: Reports showing effect of the sex of kid on body weight of kids at different stages

Breed/Genetic group	Body weight at					References
	Birth	3 Months	6 Months	9 Months	12 Months	
Sirohi	*	*	*	*	*	Mehta *et al.* (1997)
	**	**	NS	NS	NS	Pathodiya *et al.* (2003)
	**	**	**	**	**	Meel *et al.* (2010)
	**	NS	-	-	-	Sharma *et al.* (2010)
	**	**	**	**	**	Arora *et al.* (2011)
	**	**	**	**	**	Bhakar (2014)
Berari	NS	NS	NS	-	**	Kharkar *et al.* (2014)
Jamunapari	*	*	*	*	*	Roy *et al.* (1997)
	**	**	**	**	**	Rout *et al.* (2002)
	**	**	**	**	**	Singh *et al.* (2009)
	**	**	**	**	**	Singh *et al.* (2013)
Jakhrana	*	*	-	-	-	Singh *et al.* (2002)
Marwari	*	*	*	*	*	Rai *et al.* (2004)
Beetal	*	-	-	-	-	Afjal *et al.* (2004)
Tellicherry	**	**	NS	-	-	Kumar *et al.* (2005)
	**	**	**	**	**	Thiruvenkadan *et al.* (2009)
Kutchi	**	**	**	-	-	Kumar *et al.* (2007)
	*	*	*	*	NS	Yadav *et al.* (2013)
Assam Local	**	-	-	-	-	Gohain *et al.* (2014)
Sikkim local	*	-	-	-	-	Chandra *et al.* (2009)
Mahabubnagar	NS	*	*	*	*	Ekambaram *et al.* (2010)
Jakhrana	*	*	*	*	*	Mandal *et al.* (2010)
	**	**	NS	*	*	Bhusan (2012)

Black Bengal	NS	NS	*	-	*	Kumar *et al.* (2011)
	NS	-	-	-	-	Kumar *et al.* (2012)
Malabari	-	*	*	-	-	Alex and Raghavan (2012)
Osmanabadi	**	**	**	-	**	Birari *et al.* (2012)
Sangamneri	-	**	**	*	-	Jagdale *et al.* (2012)
	-	**	**	*	**	Patil *et al.* (2013)
Surti	*	*	*	*	NS	Tyagi *et al.* (2013)
Ettawah grade	**	**	-	-	-	Sodiq (2012)
Angora	**	-	-	-	**	Liu *et al.* (2005)
Draa	**	**	**	-	-	Boujenane and Hazzab (2008)
Markhoz	**	**	**	**	**	Rashidi *et al.* (2008)
Iraqi local	**	**	**	**	**	Hermiz *et al.* (2009)
Raeini	**	**	**	**	**	Mohammadi *et al.* (2012)
Teddy	**	**	**	**	**	Kuthu *et al.* (2013)
Zaraibi	**	**	**	-	-	Osman *et al.* (2013)

Note: ** = Highly significant (P≤0.01), *= Significant (P≤0.05), NS= Non-significant

Table 2.9: Reports showing effect of the dam's weight at kidding on body weight of kids at different stages

Breed/ Genetic group	Body weight at					References
	Birth	3 Months	6 Months	9 Months	12 Months	
Sirohi	*	*	*	*	*	Mehta *et al.* (1997)
	*	-	-	-	-	Tomar *et al.* (1997)
	**	-	-	-	-	Pathodiya *et al.* (2004)
	**	NS	-	-	-	Sharma *et al.* (2010)
	**	**	**	**	**	Arora *et al.* (2011)
	**	**	NS	NS	**	Bhakar (2014)
Jamunapari	*	*	-	-	-	Khan and Sahni (1983)
	*	*	*	NS	NS	Roy *et al.* (1989)
	**	**	**	**	**	Rout *et al.* (2002)
	**	**	**	**	**	Singh *et al.* (2009)
	**	**	**	**	**	Singh *et al.* (2013)
Jakhrana	*	*	-	-	-	Singh and khan (2002)
Marwari	*	*	*	*	*	Rai *et al.* (2004)
Tellicherry	**	**	NS	--	-	Kumar *et al.* (2005)
Kutchi	*	NS	NS	NS	NS	Yadav *et al.* (2003)
	**	**	NS	-	-	Kumar *et al.* (2007)
	NS	*	*	*	*	Yadav *et al.* (2008)
	*	*	*	*	*	Yadav *et al.* (2013)
Black Bengal	*	-	-	-	-	Kumar *et al.* (2012)
Iraqi local	**	**	NS	**	**	Hermiz *et al.* (2009)

Note: ** = Highly significant (P≤0.01), *= Significant (P≤0.05), NS= Non-significant

2.3 Genetic and phenotypic parameters of body weights

The prerequisites for bringing about changes in genotypes in the desired direction to formulate efficient breeding system and selection programme are the precise estimates of genetic and phenotypic parameters *viz.* heritability, phenotypic and genetic correlations among economic traits and breeding values of the traits.

2.3.1 Heritability estimates of body weight at different ages

The potential for genetic improvement of trait is largely dependent upon its heritability and its genetic correlations with other traits. The estimates of heritability vary across traits, populations and periods. The paternal half sib method (sire model like LSMLMW package of Harvey, 1990) is generally used for the estimation of heritability.

Heritability estimates of body weight at different ages in different breeds of goats as reported by different workers are summarized in Table 2.10.

The review in Table 2.10 revealed that the heritability estimates of birth weight ranged from 0.050 ± 0.025 in Sirohi goats (Tomar *et al.*, 2000) to 0.71 ± 0.04 in Beetal half breed goats (Singh *et al.*, 2000), of 3 months body weight ranged from 0.06 ± 0.09 in Mahbubnagar goats (Ekambaram *et al.*, 2010) to 0.78 ± 0.03 in Red Sokoto goats (Akpa *et al.,* 2009), of 6 months body weight ranged from 0.10 ± 0.10 in Mahbubnagar goats (Ekambaram *et al.*, 2010) to >1.0 in Beetal half breed goats (Singh *et al.*, 2000), of 9 months body weight ranged from 0.113 ± 0.047 in Jamunapari goats (Singh *et al.*, 2013) to 0.726 ± 0.157 in Sirohi goats (Meel *et al.*, 2010) and that of yearling age ranged from 0.107 ± 0.088 in Marwari goats (Rai *et al.*, 2004) to >1 in Sirohi goats (Meel *et al.*, 2010).

In Sirohi goats heritability estimates of birth weight ranged from 0.050 ± 0.025 (Tomar *et al.*, 2000) to 0.422 ± 0.118 (Meel *et al.,* 2010), of 3 months body weight ranged from 0.104 ± 0.34 (Tomar *et al.*, 2000)

to 0.70 ± 0.114 (Bhakar (2014), of 6 months body weight ranged from 0.18 ± 0.19 (Tomar *et al.*, 2004) to 0.686 ± 0.152 (Meel *et al.*, 2010), of 9 months body weight ranged from 0.27 ± 0.17 (Mehta *et al.*, 1997) to 0.726 ± 0.157 (Meel *et al.*, 2010) and that of yearling age ranged from 0.13 ± 0.16 (Mehta *et al.*, 1997) to >1 (Meel *et al.*, 2010).

Table 2.10: Estimates of heritability of body weight of kids at different ages reported by various workers

Breed/ Genetic group	Body weight at					References
	Birth	3 Months	6 Months	9 Months	12 Months	
Sirohi	0.14±0.15	0.26±0.13	0.30±0.19	0.27±0.17	0.13 ±0.16	Mehta *et al.* (1997)
	0.050±0.025	0.104±0.34	0.209±0.047	0.308±0.056	0.3 02±0.056	Tomar *et al.* (2000)
	0.152±0.025	0.184±0.034	0.209±0.068	-	0.174±0.098	Shinde *et al.* (2002)
	0.26±0.21	0.11±0.17	0.18±0.19	-	-	Tomar *et al.* (2004)
	0.422±0.118	0.555±0.136	0.686±0.152	0.726±0.157	1.2 17±0.201	Meel *et al.* (2010)
	0.50±0.087	0.70±0.114	0.62±0.108	0.64±0.115	0.75±0. 137	Bhakar (2014)
Jamunapari	0.463±0.148	0.432±0.152	0.247±0.102	0.13 4±0.104	0.127±0.116	Roy *et al.* (1989)
	-	0.30	0.51	0.23	0.31	Roy *et al.* (1997)
	0.275±0.061	0.362±0.069	0.297±0.063	0.295±0.062	0.4 17±0.073	Singh *et al.* (2009)
	0.177±0.054	0.165±0.053	0.247±0.062	0.113±0.047	0.1 36±0.050	Singh *et al.* (2013)
Beetal half breed	0.71±0.04	0.22±0.02	>1.0	-	-	Singh *et al.* (2000)
Assam local and their crosses with Beetal	-	-	0.26±0.12	0.16±0.11	0.31±0.21	Nahardeka *et al.* (2001)

Breed	Body weight at					References
	Birth	3 Months	6 Months	9 Months	12 Months	
Barbari	0.172±0.068	0.299±0.082	0.169±0.066	-	-	Singh and Rout (2001)
Marwari	0.230±0.12	0.183±0.103	0.251±0.368	0.266±0. 119	0.107±0.088	Rai *et al.* (2004)
Kutchi	0.090±0.088	0.232±0.116	0.161±0.102	0.204±0. 110	0.185±0.107	Yadav *et al.* (2013)
Tellicherry	0.091 ±0.099	-	-	-	-	Thiruvenkadan *et al.* (2008)
	0.062 ± 0.069	0.344 ± 0.163	0.369 ± 0.158	0.298 ± 0.114	0.227 ± 0.110	Thiruvenkadan *et al.* (2009)
Common African and Alpine crossbred	0.68±0.14	0.49±0.16	0.43±0.16	-	-	Mourad and Anous (1998)
Red Sokoto	0.59± 0.02	0.78 ±0.03	0.70 ±0.03	0.63 ±0 .03	-	Akpa *et al.* (2009)
Iraqi Local	0.30	0.38,	0.17	0.19	0.28	Hermiz *et al*. (2009)
Mahbubnagar	0.08 ± 0.07	0.06 ± 0.09	0.10 ± 0.10	0.21 ± 0.13	0.21 ± 0.13	Ekambaram *et al.* (2010)
Balkan	0.153±0.041	0.110±0.044	0.121±0.057	-	0.138± 0.045	Petrovic *et al.* (2012)

2.3.2 Genetic correlations

The correlation between two traits may be due to common genetic factors, common environmental factors or both. In genetic studies, it is however, essential to distinguish these two causes of correlation between traits. The genetic correlation may be due to different causes such as pleiotropy, linkage and heterozygosity. However, the major cause of these correlations is pleiotropy where one gene affects two or more traits simultaneously.

A knowledge of genetic correlation between different traits is useful in formulating a breeding programme because it determines the direction and magnitude of genetic improvement in other traits (correlated response) when selection is based on any one of these traits.

The coefficients of genetic correlations between body weights at different ages as estimated by various workers in different breeds of goats are presented in Table 2.11. All researchers observed positive genetic correlation between body weights at different age except Tomar *et al.* (2000) and Meel *et al.* (2010) in Sirohi goats, Singh *et al.* (2009) in Jamunapari goats and Ekambaram *et al.* (2010) in Mahbubnagar goats who estimated negative genetic correlations.

2.3.3 Phenotypic correlations

The phenotypic correlation is the degree of relationship between phenotypic values of different traits measured on the same animals. It is a combined function of the genotype and the environment and interaction if any, between the two traits but their relative contribution are varied.

Estimates of phenotypic correlations between body weights at different ages reported by various workers are presented in Table 2.12.

Table 2.11: Estimates of Genetic correlations among the body weights of kids reported by various workers

Traits	3 WT	6 WT	9 WT	12 WT	References
BWT	-0.179±0.209	-0.151±0.262	-0.248±0.266	-0.33±0.239	Tomar *et al.* (2000)
	0.55±0.20	0.08±0.30	0.33±0.23	0.09±0.31	Rout *et al.* (2002)
	0.425±0.325	0.114±0.368	0.241±0.340	0.335±0.432	Rai *et al.* (2004)
	0.788±0.384	0.337±0.524	0.142±0.529	0.238±0.528	Yadav *et al.* (2008)
	0.39	0.10	0.13	0.12	Hermiz *et al.* (2009)
3 WT	-	0.875±0.069	0.747±0.112	>1.0	Tomar *et al.* (2000)
	-	0.50±0.22	0.73±0.19	0.27±0.30	Rout *et al.* (2002)
	-	0.592±0.23	0.331±0.334	0.416±0.417	Rai *et al.* (2004)
	-	0.635±0.240	0.758±0.185	0.843±0.174	Yadav *et al.* (2008)
	-	0.19	0.17	0.33	Hermiz *et al.* (2009)
6 WT	-	-	0.946±0.30	0.993±0.011	Tomar *et al.* (2000)
	-	-	0.97±0.08	0.44±0.29	Rout *et al.* (2002)
	-	-	0.853±0.106	0.927±0.192	Rai *et al.* (2004)
	-	-	0.969±0.051	1.081±0.075	Yadav *et al.* (2008)
	-	-	0.31	0.22	Hermiz *et al.* (2009)
9 WT	-	-	-	0.58±0.23	Rout *et al.* (2002)
	-	-	-	0.942±0.125	Rai *et al.* (2004)
	-	-	-	1.011±0.029	Yadav *et al.* (2008)
	-	-	-	0.60	Hermiz *et al.* (2009)

Note: BWT=Birth weight, 3WT=3 months body weight, 6WT=6 months body weight, 9 WT=9 months body weight, 12 WT=12 months body weight

Traits	3 WT	6 WT	9 WT	12 WT	References
BWT	0.313±0.142	–0.012±0.169	0.123±0.166	0.129±0.152	Singh *et al.* (2009)
	0 .685 ± 0.526	0.378 ± 0.417	0.291 ± 0.455	0.075 ± 0.362	Thiruvenkadan *et al.* (2009)
	-1.71 ± 4.21	-1.16 ± 0.53	-0.92 ± 0.14	-1.17 ± 0.35	Ekambaram *et al.* (2010)
	-0.009±0.212	-0.109±0.202	-0.239±0.193	0.239±0.184	Meel *et al.* (2010)
	0.497±0.191	0.247±0.198	0.191±0.258	0.177±0.245	Singh *et al.* (2013)
	0.33	0.19	0.32	0.54	Bhakar (2014)
3 WT	-	0.370±0.128	0.354±0.133	0.289±0.130	Singh *et al.* (2009)
	-	0.816 ± 0.113	0.611 ± 0.164	0.882 ± 0.238	Thiruvenkadan *et al.* (2009)
	-	0.98 ± 0.05	1.18 ± 0.25	0.88 ± 0.16	Ekambaram *et al.* (2010)
	-	0.860±0.056	0.692±0.105	0.633±0.115	Meel *et al.* (2010)
	-	0.358±0.180	0.457±0.210	0.491±0.199	Singh *et al.* (2013)
	-	0.81	0.80	0.83	Bhakar (2014)
6 WT	-	-	0.839±0.050	0.65±0.08.9	Singh *et al.* (2009)
	-	-	0.640 ± 0.056	0.887 ± 0.141	Thiruvenkadan *et al.* (2009)
	-	-	1.01 ± 0.01	1.04 ± 0.03	Ekambaram *et al.* (2010)
	-	-	0.919±0.035	0.862±0.053	Meel *et al.* (2010)
	-	-	0.810±0.086	0.608±0.139	Singh *et al.* (2013)
	-	-	0.93	0.86	Bhakar (2014)
9 WT	-	-	-	0.863±0.040	Singh *et al.* (2009)
	-	-	-	0.939 ± 0.085	Thiruvenkadan *et al.* (2009)
	-	-	-	0.98 ± 0.01	Ekambaram *et al.* (2010)
	-	-	-	0.967±0.021	Meel *et al.* (2010)
	-	-	-	0.802±0.093	Singh *et al.* (2013)
	-	-	-	0.90	Bhakar (2014)

Table 2.12: Estimates of phenotypic correlations among the body weights of kids reported by various workers

Traits	3 WT	6 WT	9 WT	12 WT	References
BWT	0.374	0.242	0.142	0.150	Tomar *et al.* (2000)
	0.41	0.28	0.25	0.18	Rout *et al.* (2002)
	0.537	0.485	0.403	0.373	Rai *et al.* (2004)
	0.354	0.313	0.261	0.253	Yadav *et al.* (2008)
	0.22	0.18	0.22	0.20	Hermiz *et al.* (2009)
3 WT	-	0.693	0.532	0.511	Tomar *et al.* (2000)
	-	0.68	0.54	0.36	Rout *et al.* (2002)
	-	0.841	0.664	0.548	Rai *et al.* (2004)
	-	0.727	0.672	0.619	Yadav *et al.* (2008)
	-	0.66	0.54	0.55	Hermiz *et al.* (2009)
6 WT	-	-	0.748	0.749	Tomar *et al.* (2000)
	-	-	0.77	0.50	Rout *et al.* (2002)
	-	-	0.803	0.663	Rai *et al.* (2004)
	-	-	0.903	0.831	Yadav *et al.* (2008)
	-	-	0.70	0.64	Hermiz *et al.* (2009)
9 WT	-	-	-	0.822	Tomar *et al.* (2000)
	-	-	-	0.79	Rout *et al.* (2002)
	-	-	-	0.819	Rai *et al.* (2004)
	-	-	-	0.920	Yadav *et al.* (2008)
	-	-	-	0.75	Hermiz *et al.* (2009)

Traits	3 WT	6 WT	9 WT	12 WT	References
BWT	0.423	0.344	0.299	0.267	Singh *et al.* (2009)
	0.314 ± 0.168	0.336 ± 0.169	0.256 ± 0.114	0.159 ± 0 .110	Thiruvenkadan *et al.* (2009)
	0.12	0.14	0.11	0.11	Ekambaram *et al.* (2010)
	0.167	0.168	0.170	0.105	Meel *et al.* (2010)
	0.363	0.351	0.322	0.287	Singh *et al.* (2013)
	0.25	0.21	0.21	0.22	Bhakar (2014)
3 WT	-	0.76	0.567	0.466	Singh *et al.* (2009)
	-	0.781 ± 0.286	0.703 ± 0.301	0.545 ± 0.212	Thiruvenkadan *et al.* (2009)
	-	0.40	0.37	0.32	Ekambaram *et al.* (2010)
	-	0.761	0.595	0.496	Meel *et al.* (2010)
	-	0.693	0.589	0.482	Singh *et al.* (2013)
	-	0.63	0.51	0.43	Bhakar (2014)
6 WT	-	-	0.829	0.678	Singh *et al.* (2009)
	-	-	0.913 ± 0.458	0.802 ± 0.356	Thiruvenkadan *et al.* (2009)
	-	-	0.46	0.42	Ekambaram *et al.* (2010)
	-	-	0.811	0.680	Meel *et al.* (2010)
	-	-	0.833	0.853	Singh *et al.* (2013)
	-	-	0.70	0.57	Bhakar (2014)
9 WT	-	-	-	0.859	Singh *et al.* (2009)
	-	-	-	0.886 ± 0.414	Thiruvenkadan *et al.* (2009)
	-	-	-	0.46	Ekambaram *et al.* (2010)
	-	-	-	0.786	Meel *et al.* (2010)
	-	-	-	0.892	Singh *et al.* (2013)
	-	-	-	0.77	Bhakar (2014)

Note: BWT=Birth weight, 3WT=3 months body weight, 6WT= 6 months body weight, 9 WT=9 months body weight, 12 WT=12 months body weight

2.4 Morphometric traits at different ages:

2.4.1 Birth:

The overall means for body measurements as reported by various workers in various breeds of goats are presented in Table 2.13. The overall means for body length at birth ranged between 28.32 ± 0.02 cm (Pathodiya *et al*., 2003) to 32.81 ± 0.20 cm (Pathodiya *et al*., 2002), body height at birth ranged between 30.94 ± 0.13 cm (Pathodiya *et al*., 2003) to 34.96 ± 0.11 cm (Joshi, 1991) and body girth at birth ranged between 30.86 ± 0.27 cm (Tomar *et al*., 2001) to 32.16 ± 0.12 cm (Joshi *et al*., 1991) in Sirohi kids. Whereas, in other breeds of goats, the overall body length, body height and body girth at birth ranged between 19.14 ± 0.76 cm (Barua *et al*., 2002 in Assam Local to 32.74 ± 0.65 cm (Karna *et al*., 2001) in Chegu, 19.60 ± 0.86 cm (Barua *et al*., 2002) in Assam Local to 34.93 ± 0.25 cm (Kumar *et al*., 1992) in Jamunapari and 19.55 ± 0.84 cm, (Barua *et al*., 2002) in Assam Local to 35.41 ± 0.36 cm (Singh and Sengar, 1990) in Jamunapari, respectively.

2.4.2 Three Month:

The breed-wise literature reviewed on 3 months body measurements is presented in Table 2.13. The overall body length, body height and body girth at 3 months ranged between 44.40 ± 0.16 cm (Pathodiya *et al*., 2004) to 52.58 ± 0.23 cm (Joshi, 1991); 46.52 ± 0.14 cm (Pathodiya *et al*., 2004) to 56.20 ± 0.15 cm (Joshi, 1991) and 48.01 ± 0.40 cm (Tomar) *et al*., 2001) to 52.21 ± 0.12 cm (Joshi, 1991), respectively in Sirohi kids. However, in other breeds of goats a wide range for overall 3 months body length, body height and body girth was evident from the literature reviewed which ranged between 36.02 ± 0.36 (Patro and Mishra, 1987) in Ganjam to 47.72 ± 0.65 (Thiruvenkadan *et al*., 2000) in Kanni Adu; 36.40 ± 0.41cm (Barua *et*

al., 2002) in Beetal to 54.46 ± 0.75 cm (Thiruvendadan *et al*., 2000) in Kanni Adu, and 36.52 ± 0.43 cm (Barua *et al*., 2002) in Beetal to 48.05 ± 0.67 cm (Thiruvendadan *et al*., 2000)) in Kanni Adu goats, respectively.

Table 2.13: Estimates of least-squares means (cm) of body measurements of goats reported by different workers

Breeed / Genetic group	**Least squares means (cm)**			**References**
At Birth	Body length	Body height	Body girth	
Sirohi	30.73 ± 0.13	34.96 ± 0.11	32.16 ± 0.12	Joshi (1991)
	31.07 ± 0.22	34.77 ± 0.25	30.86 ± 0.27	Tomar *et al.* (2001)
	32.81 ± 0.20	33.16 ± 0.21	31.95 ± 0.23	Pathodiya *et al.* (2002)
	28.32 ± 0.02	30.94 ± 0.13	31.21 ± 0.12	Pathodiya *et al.* (2003)
	28.54 ± 0.42	32.18 ± 0.41	31.07 ± 0.34	Pathodiya *et al.* (2004)
	28.56 ± 0.08	31.31 ± 0.09	31.25 ± 0.08	Pathodiya (2004)
	30.80 ± 0.29	28.25 ± 0.32	31.14 ± 0.35	Sharma *et al.* (2010)
Assam Local	19.14 ± 0.76	19.60 ± 0.86	19.55 ± 0.84	Barua *et al.* (2002)
Barbari	25.97 ± 0.83	28.08 ± 0.70	29.52 ± 0.78	Kumar and Singh (1983)
	22.58 ± 0.17	27.45 ± 0.17	28.27 ± 0.16	Singh and Sengar (1990)
	26.97	27.44	27.51	Singh and Rout (2001)
Berari	30.09± 0.36	32.24 ±0.32	31.40± 0.31	Kharkar *et al.* (2014)
Beetal	30.17 ± 0.29	31.80 ± 0.28	34.85 ± 0.28	Singh and Sengar (1990)
	21.55 ± 0.49	21.66 ± 0.48	21.76 ± 0.49	Barua *et al.*(2002)
Black Bengal	22.88 ± 0.27	26.67 ± 0.41	25.13 ± 0.33	Kumar and Singh (1983)
	21.86 ± 0.11	23.24 ± 0.09	24.42 ± 0.12	Singh and Sengar (1990)
Ganjam	25.98 ± 0.39	32.94 ± 0.36	30.66 ± 0.40	Patro and Mishra (1987)

Jamunapari	30.65 ± 1.39	33.48 ± 0.88	32.34 ± 1.04	Kumar and Singh (1983)
	31.73 ± 0.33	31.35 ± 0.39	35.41 ± 0.36	Singh and Sengar (1990)
	32.21 ± 0.24	34.93 ± 0.25	31.07 ± 0.23	Kumar *et al.* (1992)
Chegu	32.74 ± 0.65	29.33 ± 0.13	31.93 ± 0.20	Karna *et al.* (2001)
At 3 Months				
Sirohi	52.58 ± 0.23	56.20 ± 0.15	52.21 ± 0.12	Joshi (1991)
	47.38 ± 0.48	50.02 ± 0.48	48.01 ± 0.40	Tomar *et al.*(2001)
	44.50 ± 0.33	47.73 ± 0.47	48.75 ± 0.43	Pathodiya *et al.*(2002)
	45.46 ± 1.43	47.18 ± 1.29	48.95 ± 1.35	Pathodiya *et al.* (2003)
	44.40 ± 0.16	46.52 ± 0.14	48.62 ± 0.76	Pathodiya *et al.* (2004)
	46.38 ± 0.55	44.12 ± 0.60	48.91 ± 0.69	Sharma *et al.* (2010)
Berari	44.48± 0.74	46.39± 0.73	45.59± 0.65	Kharkar *et al.* (2014)
Assam Local	37.56 ± 0.74	37.42 ± 0.77	37.68 ± 0.75	Barua *et al.* (2002)
Barbari	43.68	44.18	44.63	Singh and Rout (2001)
Beetal	36.50 ± 0.42	36.40 ± 0.41	36.52 ± 0.43	Barua *et al.* (2002)
Ganjam	36.02 ± 0.36	43.18 ± 0.88	39.96 ± 0.46	Patro and Mishra (1987)
Jamunapari	45.96 ± 0.58	47.74 ± 0.68	47.74 ± 0.68	Kumar *et al.*(1992)
Kanni Adu	47.72 ± 0.65	54.46 ± 0.75	48.05 ± 0.67	Thiruvendan *et al.* (2000)
Malabari	41.91 ± 1.27	44.83 ± 1.09	45.32 ± 1.21	Raghavan and Hari kumar (2002)

At 6 Month				
Sirohi	57.94 ± 0.05	62.05 ± 0.14	57.56 ± 0.15	Joshi (1991)
	55.02 ± 0.67	57.14 ± 0.70	56.35 ± 0.71	Tomar *et al.* (2001)
	45.77 ± 0.37	49.10 ± 0.54	51.43 ± 0.53	Pathodiya *et al.*(2002)
	50.02 ± 0.25	52.06 ± 0.24	55.16 ± 0.25	Pathodiya *et al.* (2003)
	49.55 ± 0.19	51.63 ± 0.23	54.83 ± 0.15	Pathodiya (2004)
Berari	52.23 ±0.64	58.08 ±0.55	55.86± 0.50	Kharkar *et al.* (2014)
Assam Local	41.34 ± 0.71	41.37 ± 0.70	41.46 ± 0.71	Barua *et al.* (2002)
Barbari	47.99 ± 1.04	48.00 ± 0.98	50.08 ± 1.12	Kumar and Singh (1983)
Beetal	41.50 ± 0.44	41.34 ± 0.43	41.54 ± 0.44	Barua *et al.* (2002)
Black Bengal	42.31 ± 0.75	43.52 ± 0.72	44.41 ± 0.78	Kumar and Singh (1983)
Ganjam	46.62 ± 041	54.66 ± 0.41	50.30 ± 0.46	Patro amd Mishra (1987)
Jamunapari	55.83 ± 1.19	55.23 ± 1.26	53.81 ± 1.29	Kumar and Singh (1983)
	52.27 ± 0.71	54.47 ± 0.84	50.68 ± 0.86	Kumar *et al.*(1992)
Kanni Adu	52.60 ± 0.57	61.26 ± 0.68	53.55 ± 0.59	Thiruvendadan *et al.* (2000)
Malabari	47.26 ± 1.51	49.78 ± 1.12	50.92 ± 1.81	Raghavan and Hari Kumar (2002)
At 9 Month				
Sirohi	55.50 ± 0.38	58.46 ± 0.39	60.88 ± 0.33	Pathodiya *et al.* (2003)
	54.50 ± 0.24	57.48 ± 0.19	59.08 ± 0.18	Pathodiya *et al.*(2004)
Barbari	56.82	56.37	56.82	Singh and Rout (2001)

Ganjam	49.50 ± 0.37	56.9 ± 0.47	53.60 ± 0.26	Patro and Mishra (1987)
Jamunapari	57.85 ± 1.68	59.68 ± 1.34	55.96 ± 1.38	Kumar *et al.*(1992)
Kanni Adu	56.12 ± 0.70	57.13 ± 0.85	64.26 ± 0.67	Thiruvendadan *et al.* 2000)
At 12 Month				
Sirohi	59.90 ± 0.47	63.51 ± 0.51	66.11 ± 0.45	Pathodiya *et al.* (2003)
	58.09 ± 0.29	61.92 ± 0.26	64.07 ± 0.25	Pathodiya *et al.* (2004)
Berari	57.07± 0.56	60.06± 0.56	64.35± 0.49	Kharkar *et al.* (2014)
Barbari	62.00	62.50	62.53	Singh and Rout (2001)
Ganjam	52.32 ± 0.29	60.28 ± 0.30	56.36 ± 0.27	Patro and Mishra (1987)
Jamunapari	60.99 ± 1.48	63.35 ± 1.41	59.72 ± 0.40	Kumar *et al.* (1992)
Kanni Adu	59.16 ± 0.62	67.19 ± 0.71	60.44 ± 0.64	Thiruvenkadan *et al.(*2000)

2.4.3 Six Months

The means for 6 months body measurements in various breeds of goats are presented in Table 2.13. The table indicates that the overall 6 months body length, body height and body girth ranged between 45.77 ± 0.37 cm (Pathodiya *et al.,* 2002) to 57.94 ± 0.05 cm (Joshi 1991); 49.10 ± 0.54 cm (Pathodiya *et al.,* 2002) to 62.05 ± 0.14 cm (Joshi, 1991) and 51.43 ± 0.53 cm (Pathodiya *et al.,* 2002) to 57.56 ± 0.15 cm (Joshi, 1991) in Sirohi goats, respectively. While, in other goat breed, overall body length, body height and body girth ranged between 41.34 ± 0.71 cm (Barua *et al.,* 2002) in Assam local to 55.83 ± 1.19 cm, (Kumar and Singh, 1983) in Jamunapari; 41.34 ± 0.43 cm (Barua *et al.,* 2002) in Beetal to 61.26 ± 0.68 cm (Thiruvenkadan *et al.,* 2000) in Kanni Adu and 41.46 ± 0.71 cm (Barua *et al.* 2002) in Assam local to 53.81 ± 1.29 cm, (Kumar and Singh, 1983) in Jamunapari, respectively.

2.4.4 Nine Months

The literature reviewed for 9 months body measurements are presented in Table 2.13. The overall 9 months body measurements in Sirohi breed was 55.50 ± 0.38 cm and 54.50 ± 0.24 cm of body length, 58.46 ± 0.39 cm and 57.48 ± 0.19 cm of body height, 60.88 ± 0.33 cm and 59.08 ± 0.18 cm of body girth (Pathodiya, 2003 and Pathodiya *et al.,* 2004). Whereas, in other breeds of goats, a wide range for overall 9 months body length, body height and body girth was evident from the literature reviewed which ranged between 49.50 ± 0.37 cm (Patro and Mishra, 1987) in Ganjam to 57.85 ± 1.68 cm, (Kumar *et al.,* 1992) in Jamunapari, 56.37 cm (Singh and Rout 2001) in Barbari to 59.68 ± 1.34 cm (Kumar *et al.,* 1992) in Jamunapri and 53.30 ± 0.26 cm (Patro and Mishra, 1987) in Ganjam to 64.26 ± 0.67 cm (Thiruvenkadan *et al.,* 2000) in Kanni Adu goat, respectively.

2.4.5 Twelve Months:

The literature reviewed for 12 months body measurements are presented in Table 2.13. Overall body measurements at 12 months in Sirohi goats was 59.90 ± 0.47 cm, and 58.09 ± 0.29 cm of body length, 63.51 ± 0.51 cm, 61.92 ± 0.26 cm of body height, 66.11 ± 0.45 cm and 64.07 ± 0.25 cm of body girth. (Pathodiya, 2003 and Pathodiya *et al.,* 2004). However, in other breeds of goats the overall 12 months body length, body height and body girth ranged between 52.32 ± 0.29 cm (Patro and Mishra*,* 1987) in Ganjam to 62.00 cm (Singh and Rout 2001) in Barbari; 60.06 ± 0.56 cm (Kharkar *et al.,* 2014) in Berari to 67.19 cm (Thiruvenkadan *et al.,* 2000) in Kanni Adu and 56.36 ± 0.27 cm (Patro and Mishra, 1987) in Ganjam, to 64.35 ± 0.49 cm (Kharkar *et al.,* 2014) in Berari, respectively.

2.5 Factors affecting morphometric traits

2.5.1 Genetic factors affecting morphometric traits

Sire:

Kumar *et al.* (1992) reported highly significant effect of sire on 3 months body length, significant effect of sire on 3 and 6 months body height and highly significant effect of sire on 9 and 12 month body girth while non-significant effect of sire on body length at birth, 6, 9 and 12 months of age, body height at birth, 9 and 12 months of age, body girth at birth, 3 and 6 month of age in Jamunapari goats. Karna *et al.* (2001) reported highly significant effect of sire on body length at birth and non-significant effect of sire on body height at birth in Chegu goats (Table 2.14).

2.5.2 Non-genetic factors affecting morphometric traits

Location:

Joshi (1991) reported highly significant effect of location on all body measurements at different stages of age, body height at birth and

6 months of age and body girth at birth and 6 months of age, while body length at birth, 3 and 6 months of age except body height and body girth at 3 months of age were non-significant in Sirohi goats. Sharma *et al*. (2010) observed highly significant effect of cluster on body height and body length at birth and 3 months of age in Sirohi goats, body girth at 3 months of age. Whereas Rao and Patro (2002) reported non-significant effect of location on all the body measurement up to 12 months ages except body length and body girth at birth in Ganjam goats. Kharkar *et al.,* (2014) was reported significant effect of location on body length at birth, non-significant effect of location on body length at 3 months of age and body height at birth. (Table 2.14).

Year of birth:

Khan and Sahni (1983) reported the highly significant effect of year of birth on body length at 3 months of age and significant effect on body height at 3 months of age, while non-significant effect on body length and body height at birth and body girth at birth and 3 months of age in Jamunapari goats. Kumar *et al.* (1992) reported highly significant effect of year of birth on body length at 3 month of age, body height at birth, 3 and 6 months of age and body girth at birth, 3, 6 and 9 month of age. While non-significant effect of year of birth on body length at birth, 6, 9 and 12 months of age, body height at 9 and 12 months of age and body girth at 12 months of age in Jamunapari goats.

Karna *et al.* (2001) reported highly significant effect of year of birth on body length, body height and body girth at birth in Chegu goat. Tomar *et al.* (2001) reported highly significant effect of year of birth on body length at birth, 3 and 6 months of age, body height at 3 and 6 months of age and body girth at birth, 3 and 6 months of age, while non-significant effect of year of birth on body height at birth, Sharma *et al*. (2010) observed highly significant effect of cluster on all three

morphometric traits at birth and 3 months of age in Sirohi goats (Table 2.14).

Season of birth:

In Sirohi goats, Joshi (1991) reported highly significant effect of season of birth on body length at 3 and 6 months of age, body height at birth, 3 and 6 months of age and body girth at birth and 3 months of age. He also reported non-significant effect of season of birth on body length at birth and body girth at 6 months of age. Pathodiya *et al.* (2004) reported significant effect of season of birth on body length, body height and body girth at birth. Sharma *et al.* (2010) reported significant effect of season of birth on body height and body length at birth, highly significant effect on all three morphometric traits at 3 months of age.

Khan and Sahni (1983) reported highly significant effect of season of kidding on body length at 3 months, significant effect on body height at 3 and 6 months in Jamunapari goats. They also reported non-significant effect on body length and body height at birth and body girth at birth and 3 months. Karna *et al.* (2001) reported highly significant effect of season of birth on body length at birth while its effect was non-significant on body height and body girth at birth in Chegu goats.

Sex of kid:

Highly significant effect of sex of kid on body length at birth and 6 months of age, body height and body girth at birth, 3 and 6 months of age reported was by Joshi (1991) in Sirohi goats. Tomar *et al., (*2001) reported highly significant effect of sex of kid on body length at birth and 6 months of age, body height and body girth at birth, 3 and 6 months of age in Sirohi goats. Significant effect of sex of kid on body length, body height and body girth at birth has been reported by Pathodiya *et al.* (2004) in Sirohi goats. Sharma *et al.* (2010) reported

highly significant effect of sex of kid on body length and body girth at birth whereas 3 months measurements were non-significant in Sirohi goats. Kumar *et al.* (1992) reported significant effect of sex of kid on body length and body height at birth, 6, 9 and 12 months of age while body girth at birth, 3, 6, 9 and 12 months of age in Jamunapari (Table 2.14).

Khan and Sahni (1983) reported this effect as significant at 3 months age on body length and body height, while body girth at birth. Rao and Patro (2002) reported non-significant of sex of kid on all three body measurements in all age groups.

Type of birth:

Most of the researchers have reported highly significant effect of type of birth on body length, body height and body girth at different ages and in different breeds (Table 2.14). However, Joshi (1991) reported type of birth as highly significant on body length at birth, body height at birth and 6 months of age, body girth at birth, 3 and 6 months of age, also reported non-significant effect of type of birth on body length at 3 and 6 months of age and body height at 3 months of age. Sharma *et al.* (2010) reported highly significant effect of type of birth on all three morphometric traits at birth, significant effect on body height at 3 months of age. Kumar *et al*. (1992) reported highly significant effect of type of birth on body length, body height and body girth at birth, 3 and 6 months of age, also reported non-significant of type of birth on all morphometric traits at 9 and 12 months of age in Jamunapari goats.

Table 2.14. Reports showing effect of various factors on morphometric traits of goats.

Breed	Body length					Body height					Body girth					References
	Birth	3M	6M	9M	12M	Birth	3M	6M	9M	12M	Birth	3M	6M	9M	12M	
I. SIRE																
Jamunapari	NS	**	NS	NS	NS	NS	*	*	NS	NS	NS	NS	NS	**	*	Kumar *et al.* (1992)
Chegu	**	-	-	-	-	NS	-	-	-	-	-	-	-	-	-	Karna *et al.* (2001)
II. LOCATION																
	**	**	**	-	-	**	NS	**	-	-	**	NS	**	-	-	Joshi (1991)
Sirohi	*	**				*	**				NS	**				Sharma *et al*. (2010)
Ganjam	*	NS	-	NS	NS	NS	NS	-	NS	NS	**	NS	-	NS	NS	Rao and Patro (2002)
Berari	*	NS	-	-	-	NS	-	-	-	-	-	-	-	-	-	Kharkar *et al.* (2014)
III. YEAR OF BIRFTH																
	**	**	**	-	-	NS	**	*	-	-	**	**	**	-	-	Tomar *et al.* (2001)
Sirohi	**	**				**	**				**	**				Sharma *et al*. (2010)
Chegu	**	-	-	-	-	**	-	-	-	-	**	-	-	-	-	Karna *et al.* (2001)
Jamunapari	NS	**	-	-	-	NS	*	-	-	-	NS	NS	-	-	-	Khan and Sahni 1983)
	NS	**	NS	NS	NS	*	**	*	NS	NS	**	**	*	*	NS	Kumar *et al.* (1992)
IV. SEASON OF BIRTH																
	NS	**	**	-	-	*	**	**	-	-	**	*	NS	-	-	Joshi (1991)
	*	-	-	-	-	*	-	-	-	-	*	-	-	-	-	Pathodiya *et al.* (2004)
Sirohi	*	**				*	**				NS	**				Sharma *et al*. (2010)
Chegu	**	-	-	-	-	NS	-	-	-	-	NS	-	-	-	-	Karna *et al.* (2001)
Berari	NS	**	NS	-	NS	NS	*	NS	-	**	*	NS	NS	-	*	Kharkar *et al.* (2014)
Jamunapari	NS	**	-	-	-	NS	*	*	-	-	NS	NS	-	-	-	Khan and Sahni (1983)
V. SEX OF KID																
Sirohi	**	NS	**	-	-	**	**	**	-	-	**	**	**	-	-	Joshi (1991)
	**	NS	*	-	-	**	**	**	-	-	**	**	**	-	-	Tomar *et al.* (2001)
	*	-	-	-	-	*	-	-	-	-	*	-	-	-	-	Pathodiya *et al.* (2004)
	**	NS				NS	NS				**	NS				Sharma *et al*. (2010)

Breed	Body length					Body height					Body girth					References
	Birth	3M	6M	9M	12M	Birth	3M	6M	9M	12M	Birth	3M	6M	9M	12M	
Ganjam	NS	NS	-	NS	NS	NS	NS	-	NS	NS	NS	NS	-	NS	NS	Rao and Patro (2002)
Berari	NS	NS	NS	-	NS	NS	NS	NS	-	*	NS	NS	NS	-	NS	Kharkar *et al.* 2014)
Jamunapari	**	NS	*	*	**	**	NS	**	**	**	*	*	**	**	**	Kumar *et al.* (1992)
	NS	*	-	-	-	NS	*	-	-	-	*	NS	-	-	-	Khan and Sahni (1983)
VI. TYPE OF BIRTH																
Sirohi	**	NS	NS	-	-	**	NS	**	-	-	**	**	**	-	-	Joshi (1991)
	**	**	**	-	-	*	**	**	-	-	**	**	**	-	-	Tomar *et al.* (2001)
	**	NS				**	*				**	NS				Sharma *et al*. (2010)
Berari	NS	NS	NS	-	NS	NS	NS	NS	-	NS	NS	NS	NS	-	NS	Kharkar *et al.* (2014)
Jamunapari	**	**	**	NS	NS	**	**	**	NS	NS	**	**	**	NS	NS	Kumar *et al.* (1992)
	**	**	-	-	-	**	**	-	-	-	**	**	-	-	-	Khan and Sahni (1983)
VII. PARITY OF DAM																
Sirohi	*	-	-	-	-	*	-	-	-	-	*	-	-	-	-	Pathodiya *et al.* (2004)
Assam local	NS	NS	NS	-	-	NS	NS	NS	-	-	*	*	NS	-	-	Nahardeka (2000)
VIII. DAM'S WEIGHT AT KIDDING																
Sirohi	**	**	**	-	-	*	**	**	-	-	**	**	**	-	-	Tomar *et al.* (2001)
	**	-	-	-	-	**	-	-	-	-	**	-	-	-	-	Pathodiya *et al.* (2004)
	NS	NS				NS	NS				NS	NS				Sharma *et al*. 2010)
Jamunapari	**	**	-	-	-	**	*	-	-	-	**	**	-	-	-	Khan and Sahni (1983)
	**	**	NS	NS	NS	**	**	NS	NS	NS	**	**	NS	NS	NS	Kumar *et al.* (1992)

NS = Non-Significant, ***** (P<0.05), ****** (P<0.01), 3M=3 months, 6M = 6 months, 9M = 9 months, 12M = 12 months

Parity of dam:

Pathodiya *et al*. (2004) reported that effect of parity on all morphometric traits at birth was significant. Nahardeka (2000) reported significant effect of parity on body girth at birth and 3 months of age also reported non-significant effect of parity on body length, body height at birth, 3 and 6 months of age and body girth at 6 months of age.

Dam's weight at kidding:

Highly significant effect of dam's weight at kidding on the body measurements were reported by most of the workers (Table 2.14) except Kumar *et al*. (1992) who reported this effect as non-significant on all morphometric traits at 6, 9 and 12 months of age in Jamunapari goats and Sharma *et al.* (2010) also reported non-significant effect on all morphometric traits at birth and 3 months of age.

2.6 Heritability estimates of body measurements

Tomar *et al*. (2001) reported the heritability estimates of body length as, 0.040 ± 0.153, >1.0 and > 1.0, at birth, 3 and 6 months age, respectively in Sirohi goat. The heritability estimates of body height were 0.069 ± 0.162, 0.073 ± 0.163 and >1.0 for birth, 3 and 6 months of ages, respectively. The heritability estimates of body girth were 0.238 ± 0.212, > 1.0 and > 1.0 for birth, 3 and 6 months age, respectively.

Pathodiya *et al*. (2004) reported the heritability estimate as 0.82 ± 0.72, 0.62 ± 0.19 and 0.50 ± 0.17 for body length, body height and body girth, at birth respectively in Sirohi goats.

2.1. Production performance and factors affecting it:

Singh *et al.* (2014) analysed the data on 990 Jamunapari does for milk yield (MY) at 90 days, 140 days, total lactation milk yield (TMY) and lactation length. The corresponding least squares means were 78.30±0.68, 111.42±1.50, 117.19±1.24 litres and 156.37±1.21 days, respectively. Period of kidding, parity and weight of dam at kidding affected the lactation traits significantly (P<0.01). Season of kidding and type of kidding were also (P<0.05) significant sources of variation for 90 and 140 days milk yields. Lactation length was affected by season of kidding only. Goats which delivered multiple births produced more milk (P<0.05) than those delivered single birth. Goats with higher body weight at kidding (P<0.05) produced more milk. The genetic correlations among milk production traits were high and ranged from 0.451±0.557 (90d-MY and 140d-MY) to 0.866±0.128 (90d-MY and TMY). The estimates of h2 for lactation traits were low i.e. 0.079 ± 0.054, 0.031 ± 0.048 and 0.0688 ± 0.055 for 90 days milk yield, 140 days milk yield and total milk yield, respectively.

Patel and Pandey (2013) conducted a study to evaluate production performance of Mehsana goats under farm condition at Sheep-Goat Research Station, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar. The overall means production performance traits, viz. Total lactation yield, Lactation length and Dry period was 70.23 ± 1.37 (lit), 224.00 ± 4.19 (days) and 112.31 ± 6.64 (days), respectively.

Tyagi *et al.* (2013) evaluated lactation performance of Surti goats maintained under field condition. Overall mean of lactation length, 90 days Milk yield, 150 days milk yield and total milk yield were 168.11 ± 1.84 days (231), 110.70 ± 1.10 litres (231), 166.08 ± 1.64 litres (193), 176.39 ± 2.27 litres (193) and, respectively. Effect of year, season and cluster were significant (P<0.05) on all lactation traits,

while parity was significant on all of the traits studied except lactation length.

Hassan *et al* (2010) studied the productive efficiency of Jamunapari goats. The average lactation yield was 68.5 ± 35.9 litres and 72.8 ± 25.5 litres, lactation length was 135.4 ± 14.9 days and 143.9 ± 13.2 days for does suckling one and two kids, respectively. Highest milk yield was in second month and lowest in the fifth month after kidding.

Mandal *et al.* (2010) analysed data on milk production of Jakhrana breed of goats. The overall least-squares means for 90 days milk yield, 140 days milk yield, total milk yield and lactation length of animals were 101.98±2.38, 144.60±3.53, 166.05±5.21 litre and 183.04±4.04 days, respectively. The kidding year, Season of kidding had highly significant ($P<0.01$) influence on all lactation traits. Significant ($P<0.05$) differences in 90 and 140 days milk yields existed among does of different lactation number.

Pathodiya *et al.* (2010) analysed data on milk production of Sirohi goats under field condition. The least square means of milk yield at 140 days, total lactation milk yield, total lactation length, peak milk yield and average daily milk yield were 56.34 ± 2.93 lit., 59.42 ± 2.18 lit., 163.28 ± 3.53 days, 562 ± 0.28 ml on peak day and 362.40 ± 15.91 ml/day, respectively . The effect of sire was also significant ($P<0.001$) on all the traits. The effect due to year of kidding was reported to be significant on total lactation milk yield and total lactation length.

Sabapara *et al.* (2010) studied production performance of Surti goats and their offspring under field conditions. The mean lactation length and lactation milk yield were recorded as 5.42±0.10 months and 273.95±1.08 litres/150 days, respectively. The results indicated that the Surti goats attained peak lactation milk yield (281.97±2.55 litres/150

days) in their 3rd lactation. It was concluded that Surti breed has high production potential along with early sexual maturity and higher multiple births.

Singh *et al.* (2010) analysed the performance data on Mehsana goats. The overall means ± SE for total lactation milk yield, lactation length, service period, dry period were 76.35 ± 1.67 kg, 219.05 ± 4.86 days, 204.19 ± 3.58 days and 110.73 ± 8.29 days, respectively.

Deshpande *et al.* (2009) carried out survey on Surti breed of goats. The selected goats were followed for a period of two years to study their reproduction and production performance along with the growth performance of kids. The test milking was done at 15 days interval till 150 days of lactation. The average lactation yield found to be at 90 days, 120 days and 150 days was 94.29 ± 2.88, at 119.01 ± 3.51 and at 138.19 ± 4.05 kg respectively.

Yadav and Khada (2009) analysed the data on productive performance of crossbred goat. The overall mean of dry period 149.87 ± 1.16 days, milk yield at 150 days 62.29 ± 2.59 litres and peak milk yield 675.25 ml were observed.

Singh and Ramachandran (2007) studied the factors affecting the lactation traits of Sirohi goats. The average total lactation yield was found to be 117.66±14.94 litres in a lactation length of 186.1 ±17.9 days. The 90 days milk yield and 140 days milk yield and the daily milk yield were 71.46±5.33 litres, 98.63±7.74 litres and 627.7±46.2 ml /day respectively and significantly varied ($P<0.01$) between years and parities. The total lactation yield increased over the parities and reached its peak in the third parity. The daily milk yield was significantly higher ($P<0.05$) in does with multiple births compared to does with single birth. The regression on dam's weight at kidding was significant ($P<0.05$) on all the lactation traits under study.

Kumar *et al.* (2006) studied the lactation performance of Kutchi goats under organized farm conditions. Overall mean of lactation performance of Kutchi goats at 90 days milk yield, 150 days milk yield, total lactation yield, lactation length and per day yield 69.13±4.01 kg, 94.72±5.10 kg, 112.56±5.65 kg, 202.5±5.65 days and 1.16±0.11 kg respectively. The highest lactation yield was recorded from the does in third parity. The yield increased up to third parity afterward decreased. It was lowest in the does of seventh parity. Does kidded in later half of the year produced more milk as compared to the does kidded in first half of a year. The peak yield was achieved in the 3 to 4 weeks of lactation period after kidding.

Gurjar *et al.* (2005) analysed the data on milk production of Sirohi goats under field condition. The Least-squares means of milk yield at 90, 150, total milk yield and total lactation length were 44.89±0.77 (lit), 66.33±1.41 (lit), 68.09±1.37 (lit.) and 154.85 ± 1.68 (days), respectively. The year and season of kidding, type of birth and parity had significant effect on all the lactational traits studied. The production traits increased gradually up to the 4th parity. The does with multiple births produced more milk in comparison to doe's having single kids. Whereas the does kidded during March to June months were better for expression of lactation traits than those kidded in other months.

Rai and Singh (2005) evaluated the production performance of Jakhrana goats. The average milk yield and lactation length were 152.87 ± 2.69 kg and 143.0 ± 3.2 days in semi intensive system and 107.39 ± 2.11 kg and 118.0 ± 2.3 days in extensive system of management. The average peak yield ranged from 1.0 to 4.1 kg with the average of 2.46 ± 0.67 kg/day indicating tremendous potential in this breed for milk production. Significantly higher lactation length and 90 days milk yield was recorded under semi intensive system as compared to extensive system of management.

Swami *et al.* (2005) studied the data of production traits of Sirohi goats and its crosses (half-bred) with Beetal. The overall lactation yield was 49.00±05.642 litres, lactation length 106.93±10.762 days, peak yield was 0.63±0.062 litres and milk yield/day of lactation 0.34±0.031 litres. Seasonal differences were significant for all production traits except lactation length. The periodic differences were highly significant for all the four production traits. Milk yield/day of lactation was also significantly influenced by type of kidding. Parity differences were significant for all the traits except milk yield/day of lactation. A gradual increasing trend up to third parity for lactation yield, lactation length and peak yield was evident and thereafter a sharp decline in performance in fourth parity was observed. The regression of dam's weight at kidding was significant on all production traits except lactation length.

Gokhale *et al.,* (1997) studied the data on nondescript and graded Sirohi goats. The raw and least-squares mean lactation yield were 128.21 ± 0.43 kg and 114.22 ± 22.62 kg in a lactation period of 167.28 ± 0.82 days respectively. The effects of location, village, parity, lactation period group, litter size, month and year of kidding, maintained by the goat owner were highly significant. The effect of sex of kid did not have any effect on the milk yield of the goats. The milk yield increased with litter size. The low milk yield in first lactation significantly increased to second lactation. The lactation yield during second to fifth lactation did not differ. August to October kidding gave higher lactation yield compared to those kidding in the other months of the year. The does kidded during 1995-96 produced more milk than those kidded during 1991-92 and 1993-94.

Misra *et al.* (1985) studied the lactational performance of Sirohi and Beetal x Sirohi born during autumn. Milk yield of the does was recorded once in each fortnight till weaning. For fortnight milk yield, post-parturient body weight of the doe was used as a covariate. Least-squares means for 90 days milk yield for Sirohi and Beetal x Sirohi

were 66.031 ± 1.799 kg and 65.531 ± 2.412 kg respectively. The regression of pre-weaning body weight on dam's milk yield was significantly high i.e. 2.417.

Misra and Rawat (1985) utilized lactation records pertaining to 90, 150 days and total milk yield in Sirohi and Beetal x Sirohi goats. Overall mean of 90 days milk yield in first, second and third lactation were 51.61 ± 2.109 kg, 67.89 ± 2.638 kg and 69.59 ± 3.19 kg, 150 days milk in first, second and third lactation were 70.80 ± 2.685 kg, 90.75 ± 3.43 kg and 92.14 ± 4.913 kg, total milk yield in first, second and third lactation were 85.74 ± 3.36 kg, 109.16 ± 4.122 kg and 109.85 ± 6.36 kg respectively in Sirohi goat. Overall mean of 90 days milk yield in first, second and third lactation were 48.59 ± 2.67 kg, 60.78 ± 2.99 kg and 71.27 ± 3.65 kg, 150 days milk in first, second and third lactation were 64.39 ± 3.07 kg, 80.72 ± 3.73 kg and 92.56 ± 4.94 kg, total milk yield in first, second and third lactation were 78.70 ± 3.71 kg, 95.28 ± 4.20 kg and 116.30 ± 5.28 kg respectively in Beetal x Sirohi goat. There was no difference ($p< 0.05$) between the two genotype with respect to part yields as well as the total yield in all 3 lactations. The effect of parity was highly significant ($p<0.01$).

Misra *et al.* (1983) reported the effect of season of breeding in goats on some reproduction and production traits in Sirohi goats viz. body weight of does at kidding in spring, summer and autumn were 29.77 ± 0.33 kg, 33.52 ± 0.23 kg and 32.41 ± 0.kg, lactation yield were 72.20 ± 2.21 kg, 60.60 ± 1.76 kg and 43.50 ± 3.43 kg, lactation length were 165.99 ± 3.73 days, 172.46 ± 2.50 days and 154.47 ± 8.49 days, respectively. Weight at kidding also differed significantly ($p<0.05$) among seasons of breeding. The summer bred (winter kidding) does were the heaviest followed by those bred in autumn and spring in descending order.

Mukundan *et al.* (1983) evaluated various factors affecting variation in milk production traits in Malabari and its Saanen half-breeds. Least-squares means of lactation yield in Malabari and Sannen half-breeds was 49.35 ± 10.24 kg and 117.30 ± 20.51 kg, lactation length 139.5 ± 20.25 days and 215.0 ± 40.53 days, dry period 162.8 ± 55.1 and 190.8 ± 76.9 days respectively, and these differences were significant. Genetic group, season of kidding and weight at kidding had significant effect on lactation yield. Lactation which were initiated in season 2 (February to April) had higher milk yield (perhaps due to the plenty of green fodder available during the monsoon). As the weight at kidding increased the lactation yield also increased. Lactation length was significantly influenced by genetic group and weight at kidding. Sannen half-breeds showed 54% longer lactation length than Malabari thereby for increasing lactation yield. Peak yield was 1.4 kg in the goats of weight group 25 kg and above. Dam's weight at kidding had significant effect on lactation length and lactation yield.

Chander *et at.* (1971) utilized the data of 1432 Beetal goats spread over period of 37 years and belonging to a closed experimental flock stationed at Hissar. The overall lactation yield was 131.7 ± 7.7 kg, lactation length 147 days, peak yield 140.3 kg, age of first kidding 107 weeks. Year (period), season of kidding, lactation number, lactation length and age at first kidding were observed to affect the milk yield significantly. Animals kidding in the months from January to June yielded more milk than those kidding in other months. Maximum yield was attained in the third lactation and there was gradual decline in the later lactations. Heritability of milk yield obtained from half-sib correlation using data adjusted for period of kidding and lactation length ranged from 0.155 ± 0.170 in 5^{th} lactation to 0.322 ± 0.166 in 3^{rd} lactation. Heritability of 0.32 ± 0.06 for the first lactation showed that substantial improvement can be made in this trait through mass selection.

2.2. Reproduction performance and factors affecting it:

Fahim *et al.* (2013) studied the reproductive performance of Rohilkhand goats. The overall least squares-means of age at first heat, age at first mating, age at first kidding and gestation length were 282.23 ± 6.51, 362.14 ± 10.04, 543.17 ± 19.47 and 149.70 ± 0.51 days, respectively. Age at first heat was significantly higher in winter born animals than in summer and rainy season born. Similarly, season affected the age at first mating.

Mia *et al.* (2013) estimated genetic and phenotypic parameter for some reproductive traits of Black Bengal does by Restricted Maximum Likelihood procedure. The least-squares means of litter size at birth (LSB), litter size at weaning (LSW), litter weight at birth (LWB), litter weight at weaning (LWW) and gestation length were 1.50, 1.29, 1.58 kg, 6.37 kg and 144.71 days, respectively. The effect of parity was significant for LSB, LSW, LWB and LWW. In general, LSB, LSW, LWB and LWW increased with the progress of parity. The effect of season of kidding was significant for LSW, LWB and LWW. Estimates of heritability for LSB, LSW, LWB, LWW and gestation length were 0.08, 0.13, 0.10, 0.00 and 0.18, respectively.

Patel and Pandey (2013) conducted a study to evaluate reproduction performance of Mehsana goats under farm condition. The overall means of reproduction performance traits, viz., weight at first mating, age at first service, service period, weight at first kidding, gestation period, age at first kidding, weight at kidding and kidding interval were estimated to be 26.00 ± 0.50 kg, 560.43 ± 20.83 days, 209.66 ± 2.90 days, 28.19 ± 0.45 kg, 148.97 ± 0.28 days, 716.52 ± 19.01 days, 31.58 ± 0.29 kg and 364.40 ± 4.32 days, respectively.

Kumar *et al.* (2012) analysed reproductive status of Sirohi goats under field conditions. The overall least squares means for age at first service (AFS), age at first kidding (AFK), weight at first service (WFS)

and weight at first kidding (WFK) were 513.70±9.01 days, 662.92±9.23 days, 26.25±0.12 kg and 28.63±0.12 kg, respectively. All these traits were the lowest in the year 2002. The AFS and AFK were the highest (595.48±20.33 and 747.38±20.82 days, respectively) in 2004. The WFS was the highest (28.04±0.24 kg) in 2006 whereas, WFK was recorded maximum (30.92±0.26 kg) in 2007. The twining and triplets percentages ranged between 11.76 and 27.15 and from 0 to 1.10%, respectively.

Chandra and Karmakar (2011) conducted a study on 82 kidding records of Sikkim local goats. The overall incidence of twin birth was 51.95%. The year and season of birth had significant effect on twining percentage. The twinning percentage was found to be 47.06% in rainy season while it was 59.26% in winter season. Twinning incidence increased after first kidding in the flock, though not uniformly up to sixth parity. Sex ratio expressed as the percentage of male births among the normal kids born and it was found to be 52.14%. The sex ratio was significantly affected by year of birth and it was lowest (47.06%) in 2001 and highest (68.75%) in 1998. The male frequency was higher (52%) in rainy season and lower in winter season (48.84%). The frequency of male birth was higher (53.75%) in the twins it was 44.74% in single births. The frequency of male birth varied from 41.67% in 4^{th} kidding to 64.71% in 5^{th} kidding also parity did not affect the sex ratio.

Ekambaram *et al.* (2011) conducted a survey on 1319 female Mahabubnagar goats. The geographical division had significant influence on age at first mating, age at first kidding, kidding interval and litter size with overall least-squares means of 304.87 ± 0.19, 455.65 ± 0.19, 254.92 ± 0.25 days and 1.89 ± 0.02 kids, respectively. Mahabubnagar goats showed nearly 70% multiple birth with 50% of twining and 20% of other kidding patterns like triplets, quadruplets, hexaplets and septuplets and relatively shorter age at first kidding and kidding intervals under field conditions.

Kumar *et al.* (2011) studied records of 351 Black Bengal and Beetal X Black Bengal does. The overall means of age of first conception and age at first kidding were 388.88 ± 4.07 days and 536.04 ± 4.04 respectively. Genetic group and birth weight had significant effect, while litter size at birth and season of birth had non-significant effect on these traits.

Rumi *et al.* (2011) analysed the data on 340 animal born over a period of 21 years belonging to three genetic groups viz. Assam Local, ½ Beetal ½ Assam Local and ¾ Beetal ¼ Assam Local maintained at the AAU, Burnihat. Reproductive traits includes age of first fertile service, age of first kidding, gestation period, service period and kidding interval were analyse by least squares technique. Analysis of variance showed significant effect ($p< 0.01$) of period of kidding and type of birth on these traits. The gestation period at period of birth 1 (144.60 ± 0.406 days) was significantly shorter than that in period of birth 2 and period of birth 3 which were 145.657 ± 0.216 and 145.745 ± 0.302 days respectively. The single born animals had shorter gestation period (144.556 ± 0.215 days) than the multiple born animals (146.111 ± 0.290 days). Genetic group and kidding order revealed significant effect ($p< 0.01$) on service period. The service period of Assam Local was found to be 107.700 ± 8.093 days which was longer than that of the two crossbreds, 81.969 ± 7.482 and 78.133 ± 11.883 days respectively. With regards to kidding order, service period was longest in third kidding order (106.730 ± 12.544 days) followed by first kidding order (90.055 ± 7.009 days) and second kidding order (71.019 ± 8.308 days).

Hassan *et al* (2010) studied the reproductive efficiency of Jamunapari goats under semi-intensive conditions. The average age at first oestrus, age at first pregnancy and age at first kidding were 354.8 ± 17.1, 395.4 ± 29.6 and 548.6 ± 68.1 days, respectively. The gestation

length was 152.8 ± 17.6 days. The average body weight just after kidding was 26.7 kg. Sex ratio was 53.3 % male to 46.7% female.

Sabapara *et al.* (2010) studied reproduction performance of Surti goats and their offspring under field conditions. The mean age at puberty, age at first kidding, kidding interval, service period and gestation length were recorded as 9.04±0.49 months, 14.28±0.38 months, 7.80±0.20 months, 2.90±0.20 months and 147.20±0.41 days, respectively. Twining was 50.89% while only 8.28 % goat kidded triplets.

Deshpande *et al.* (2009) carried out survey in the three selected districts to study the reproductive performance of Surti kids. The mean age at puberty 9.03 ± 0.53 months, age at first kidding 14.04 ± 0.56 months, kidding pattern was found single 58.10%, twins 41.35% and triplet 0.55%. Sex of kids was male 136 and female 121. The mean gestation length for Surti goats was recorded as 146.75 ± 0.55 days in field condition. The twinning percentage was recorded as 41.35 %. The male and female sex ratio was recorded as 1.00: 0.89.

Poonia *et al.* (2009) studied the factors affecting the sex ratio in Beetal goats. The results revealed that the differences between the years were not significant. Out of 1440 total births recorded, 725 (50.35 %) and 715 (49.65 %) were males and females, respectively. The month, season and type of birth-wise sex ratio revealed non-significant differences. The percentage of male was higher in the months of May to October, whereas female was higher in the months of November to April and more kiddings in the month of February-March than October-November. Out of the 1440 Beetal kids, 45.14% were born during spring followed by 27.29% in autumn, 19.65% in winter and 7.92% during summer months. The percentage of males was higher in summer and autumn season with a maximum of 57.89% during

summer season. The percentage of male was higher in single (52.90 %) and triplets (52.38 %) but the effect was not significant.

Rao *et al.* (2009) recorded the data on reproduction traits of Ganjam goats. The overall mean of age at first heat, weight at first heat, age at first kidding, weight at first kidding, service period, kidding interval and gestation length were 440.92 ± 3.13 days, 19.90 ± 0.37 kg, 618.88 ± 2.14 days, 22.97 ± 0.36 kg, 154.05 ± 1.02 days, 304.15 ± 3.17 days and 149.23 ± 2.11 days respectively. Maximum kidding is observed in winter followed by summer and rainy season. Ganjam buck attains puberty at the age of around 15-18 months with a body weight of 25-28 kg. The breeding bucks are used for service purpose for a period of 4-5 years. Type of birth of Ganjam goats under range conditions were single 99.52% and twin 0.48%.

Singh *et al.* (2009) utilized the data of Mehsana goats on reproduction traits. The overall mean of age at first oestrus was observed to be 13.59 ± 0.07 months, age at first mating 15.23 ± 0.14 months. The district-wise mean for age at first mating revealed that does from Mehsana district exhibited their first mating at lower age as compared to those from Patan and Banaskantha. This indicated that goats in Mehsana district attained puberty at an early age. The overall mean for age at first kidding (AFK) was observed to be 20.32 ± 0.13 months. The performance in three districts revealed that first kidding occurred at an early age in Mehsana district followed by Patan and Banaskantha. The overall mean for kidding interval was 322.27 ± 1.77 days.

Yadav and Khada (2009) analysed the data on reproductive performance of crossbred goat. The overall mean of age at sexual maturity of male 335.62 ± 0.96 days, weight at sexual maturity of male 24.02 ± 0.27 kg, age at sexual maturity of female 315.62 ± 1.22 days, weight at sexual maturity of female 20.02 ± 0.74 kg, age at first kidding

436.52 ± 4.34 days, weight at first kidding 23.87 ± 0.67 kg, kidding interval 308.66 ± 0.79 days, service period 158.89 ± 1.02 days and gestation length 150.34 ± 0.87 day.

Das *et al.* (2008) analysed the data of Bengal goats. The number of three colour varieties of Bengal goat for black, brown and white were 365, 230 and 230, respectively. The data on age at first oestrus in days (Black 203.24± 3.90, white 196.72 ± 4.17 and brown 199.28 ± 3.94), age at first conception in days (black 216.94± 4.36, white 200.12± 4.26 and brown 205.00± 4.23), gestation length in days (black 145.39± 0.06, white 144.34± 0.79 and brown 147.02± 0.59), age at first kidding in days (black 370.04± 4.45, white 358.17± 5.33 and brown 360.47± 4.47), kidding interval in days (black 229.05± 3.79, white 221.45± 5.31 and brown 228.93± 5.32)and birth type were analyzed. The age at first oestrus as well as at first kidding and kidding interval did not differ significantly (P<0.05) between the three colour varieties of Bengal goats. There was significant (P<0.05) difference in age at first conception and oestrus interval between black and white coloured Bengal goats.

Pathodiya *et al.* (2008) studied to explore the reproductive performance of Sirohi goats in field conditions. The overall mean for dry period, service period, kidding interval and gestation period were 183.58±13.97, 195.64±14.46, 341.53 ±13.16 and 150.12±0.40 days, respectively. The analysis of variance revealed significant effects of sire, year and season of birth on service period, dry period and kidding interval. Significant effect of year and season of kidding on these traits were obvious as service period and dry period are component of kidding interval. The effect of type of birth, location and parity of dam was found non-significant on these traits. The heritability for service period, dry period, and kidding interval were (0.631±0.232), (0.457±0.202) and (0.488±0.208) respectively.

Deokar *et al.* (2007) studied the breed characteristics of Sangamneri goat reared by farmers in its breeding tract. The overall mean of age at puberty, age at first conception, age at first kidding, service period, kidding interval and gestation period recorded in Sangamneri goats under field conditions were 9.94±0.34 months, 10.40±0.73 months, 15.52±0.48 months, 73.55±1.47 days, 218.48±10.44 days and 148.26±1.43 days, respectively. The overall twining in Sangamneri goats under field condition was 50.64 per cent. The test day milk yield in Sangamneri goats in morning, evening, total and estimated 90 days was 0.386, 0.354, 0.697 and 58.950 kg, respectively.

Maroof *et al.* (2007) studied the reproductive performance of Beetal goats in its breeding tract. The average body weight at sexual maturity was found as 28.35 ± 1.90 kg. The age at first conception, age at first kidding, kidding interval period, gestation length were observed to be 386.29 ± 4.78, 522.83 ± 5.19, 350.50 ± 6.08 and 149.04 ± 2.04 days, respectively. The kidding pattern in Beetal goats was found as 10.05, 77.76, 12.19 and 1.47 percent single, twin, triplet and quadruplet, respectively.

Roy *et al.* (2007) investigated the reproductive performance of Black Bengal goats. Out of 36 kids, the twins were 20 and 16 were single births. The percentage of birth of twin was 55.56 % & single was 44.44 %. Gestation length (in days) 143.15±0.26, 145.62±0.63, 144.08±1.01, the effect was non-significant. The percentage of male and female kids was 64.28 and 35.71.

Kumar *et al.* (2006) studied the reproductive performance of Kutchi goats at CSWRI, Avikanagar Rajasthan. Overall mean of reproduction performance of Kutchi goats of age at puberty 545.12±1.48 days (118), weight at puberty 28.30±1.10 kg (118), age at first kidding 698.41±1.49 days (118), weight at first kidding 32.88±4.12

kg (118), first gestation period 145.22±0.46 days (118), first kidding interval 411.17±50.95 days (72), kidding percentage (No. Kidded/No. Available) 70.0 and twining percent 11.68 were recorded.

Soundrarajan and Sivakumar (2006) utilized the data of 227 Kanni goats born during period of 6 years. The overall sex ratio in Kanni goat was 57.71 % male to 42.29% female (approximately 1.36:0.64). Out of the total Kanni kids born, 40.97% were born during winter followed by 23.79% each during southwest and northeast monsoon and 11.45% during summer months. The percentage of male was higher in all the seasons with a maximum of 61.54% during summer season. The percentage of male was higher in single (51.72%), twinning (61.19%) and triplets (66.67%). More number of males was observed in all the six years, with a maximum of 65.06% during 2003. The percentage of male was higher in all the months, except during February, April, June and September, with the highest rate of 72.22 to 88.89% during October, August and May months.

Swam et al (2006) *et al.* studied the reproductive performance of Sirohi goats and its crosses with Beetal in semi-arid condition of Rajasthan. The overall least squares means for gestation length was 146.01 ± 0.454 days, age of kidding was 635.16 ± 61.095 days and kidding interval was 332.54±25.933 days. The effect of period of kidding was highly significant on all reproduction traits studied except gestation length. The effect of type of birth was highly significant on gestation length only.

Kumar *et al.* (2005) analysed the data of Sirohi goats. The overall least squares means of age at first service, weight at service, age at first kidding and weight at first kidding were 646.01±19.08 days, 26.15±0.36 kg, 794.95±19.03 days and 29.66±0.41 kg services, respectively. All these traits were significantly influenced by year and season of service. Season of kidding had no significant effect on these

traits except weight at service and at kidding. The maximum variation was attributed by year of service whereas season had relatively less contribution to variation in the traits included in this study.

Patel (2005) studied the kidding performance of Marwari and Parbatsari goats under different management systems in the arid zone. Higher kidding percentage (>80 %) was observed in intensive and semi-intensive systems. Average twinning percentage was observed to be 4.5, 14.8 and 25.0 % in extensive, semi-intensive and intensive system of management, respectively. The effect of management system was found to be significant on body weights of goats at different physiological stages. The body weights of Parbatsari was significantly ($P<0.01$) higher than Marwari goats at breeding, kidding, 3 months and 6 months of lactation. The mean body weights of Marwari and Parbatsari goats irrespective of management system were 24.6 and 28.4 kg at breeding, 25.9 and 30.4 kg at kidding, 25.9 and 30.1 kg at 3 months of lactation and 21.3 and 31.3 kg at 6 months of lactation, respectively.

Pathodiya *et al*. (2005) utilized the data pertaining to 1302 kidding records of Sirohi goats kidded during 2002-2004 were used for present study. Sex ratio (Male: Female) was lowest during the year 2004 (0.86) whereas, it was highest during the year 2003 (1.10). Average kidding rate (Litter size) ranged from 1.12 to 1.17%, multiple birth was higher during the year (2002). On an average, more than 86% of the total births were single, whereas multiple birth during this period was 14%.

Rai and singh (2005) utilized the data on reproduction traits from 318 Jakhrana goats. Goats were reared under extensive system (64%) and semi intensive (36%) system of management. The average age at first kidding, kidding interval and twinning rate were 561.24± 9.83 days, 287.78 ± 9.89 days and 1.54 ± 0.16 days in semi-intensive, and 632.35

± 7.83 days, 332.86 ± 9.34 days and 1.32 ± 0.16 in extensive management system respectively. Significantly higher performance with respect to kidding interval and prolificacy was observed for does reared under semi-intensive system of management. The average milk yield and lactation length were 152.87±0.19 kg and 143.0±3.2 days in semi intensive system and 107.39±0.11 kg and 118.0±2.3 days in extensive system of management, respectively.

Das *et al.* (2004) utilized data of 389 goats from 27 sire families belonging to 3 genetic groups, viz. Assam Local, ½ Beetal ½ Assam Local and ¾ Beetal ¼ Assam Local maintained at the AAU, Burnihat covering a period of 10 years (1990-1999) were collected and analysed. The least squares means of age of first fertile service, age of first kidding, gestation length, service period and inter-kidding period were 510.50 ± 3.62, 653.46 ± 4.61, 145.01 ± 0.06, 155.64 ± 0.88 and 300.92 ± 0.89 days respectively. The gestation length of the does bearing male foetus (146.02 ± 0.07 days) was higher than those bearing female foetus (143.99 ± 0.08 days). The Assam Local goats had significant shorter Service period (137.92 ± 1.16 days) than ½ Beetal ½ Assam Local and ¾ Beetal ¼ Assam goats. Significant effect of genetic groups on age of first fertile service, age of first kidding, service period and inter-kidding period and sex of the kid on gestation length were observed. The estimates of h^2 were high for age of first fertile service (0.41± 0.28) and age of first kidding (0.37 ± 0.12).

Hossain *et al.* (2004) investigated the reproduction performance of Black Bengal goat in different parity reared in semi-intensive system during two year. Young female attainted puberty at an average age and weight of 209 ± 32.25 days and 8.08 ± 1.28 kg, respectively. Mean age and weight at 1st kidding were 401.5 ± 32.08 days and 15.41 ± 1.35 kg, respectively. Growth rate at first gestation period was 49.56 ± 9.15 gm/day. Sex ratio of male: female kid born was found to be 57 : 43. Average gestation period length of 148 days. Kidding interval also

reduced significantly ($p<0.05$) from 199 days in 2nd parity to 187 in 3rd parity. Average birth weight of male was higher (1.14 kg) than female (1.06 kg). Gestation period was affect by factors like season, year, sire and kidding interval.

Kumar *et al.* (2002) conducted the investigation on 401 kidding records of Kutchi goats maintained at CSWRI, Avikanagar during 1992 to 1996. The overall tupping percentage, conception rate and kidding percentage were 83.6%, 87.2% and 83.7% respectively in the flock. The overall frequency of twin births and abnormal kidding were 10.5% and 3.5% whereas the overall sex ratio was 50.5%. The gestation period was 147.8 days. On an average 1.10 kids were born in each parturition.

Singh *et al.* (2002) studied the genetic and non-genetic factors affecting reproduction performance of goats. Overall least squares means of age at first service, age at first kidding, litter size at birth, litter weight at birth, litter size at weaning and litter weight at weaning was 512.17 ± 15.33 days, 686.50 ± 16.26 days, 1.46 ± 0.05, 2.56 ± 0.10 kg, 1.31 ± 0.04 and 9.09 ± 0.33 kg respectively in Beetal, Black Bengal and their reciprocal crosses. Analysis of variance revealed significant effect of genetic group and year on age at first service and kidding whereas significant genetic group effect was observed in case of litter size and weight at birth and weaning both. Season affected significantly only litter size at birth.

Singh *et al.* (2000) analysed data pertaining to reproductive traits of Black Bengal and its crosses with Beetal. Overall least-square means of age at first conception and age at first kidding was 350.94 ± 11.76 days and 496.76 ± 11.76 days respectively. The AFC of Beetal half-bred was significantly higher than that of purebred Black Bengal. It did not vary due to litter size at birth and season of birth. The variation in AFK is mainly due to variation in AFC and the factors governing it. In

FKI significant variation due to genetic group observed only. The heritability estimates of reproductive traits were more than the theoretical limits, which are not significantly different from zero. This could be due to the sampling fluctuation in small sample size. The phenotypic and genetic correlations among AFC, FK, FSP and FKI were positive and high in magnitude, indicating that these factors are under the control of similar genetic and non-genetic factors.

Nahardeka et al (1995) analysed the data on reproductive performance of Assam Iocal (AL), 1/2 Assam Iocal and 1/2 Beetal (1/2 AL X 1/2 B) and 1/4 Assam Iocal 3/4 Beetal (1/4 AL X 3/4 B) goats. Overall least-squares means of age at 1st fertile service, age at 1st kidding, gestation period and kidding interval were 620.10 ± 21.90 days, 762 90 ± 21.60 days, 145.83 ± 0.17 days and 302.36 ± 10.40 days, respectively. There was significant ($P<0.05$) effect of period on 1st fertile service, age at 1st kidding, gestation period and kidding interval, also season on kidding interval.

Mukundan *et al.* (1983) utilized the data of female kids of Malabari and Sannen half-breds. Overall least-squares means of age at 1st oestrus, age at 1st kidding, weight at 1st kidding, gestation period and kidding interval were 425 ± 15 days, 557 ± 48 days, 23.2 ± 1.2 kg, 147.4 ± 1.2 days and 338 ± 41 days, respectively. The age of first kidding was significantly affected by the genetic group and year of birth.

Singh and Singh (1983) recorded the birth weight of kids, gestation length and post partum weight of dam in 123 kidding of Black Bengal, ½ Black Bengal + ½ Jamunapari, ½ Black Bengal + Beetal kids. Average values of birth weight of kids, gestation length and post partum weight of dam were 1.6 ± 0.1 kg, 142.6 ± 0.5 days and 19.7 ± 0.6 kg in single birth, 2.8 ± 0.1 kg, 140.9 ± 0.5 days and 21.3 ± 0.5 kg in twin birth, respectively.

Mishra *et al.* (1979) analysed the data of 200 kidding. Bucks of Sirohi and Beetal breeds were involved in breeding of Sirohi does. The overall gestation length of Sirohi does in four different season was 146.41 ± 0.24. The range of gestation length in Sirohi was 139 to 159 days. The effect of breed of sire, season of kidding and sex of the kid, and their interactions were statistically non-significant. This showed that breeding in any of the 4 breeding season did not affect seriously the gestation length. The correlation of gestation length with weight of the kid at birth and weight of the doe at service were 0.33 and 0.413, respectively, and were highly significant ($p<0.01$). The correlation between gestation length and post-parturient body weight of dam was positive 0.12 but statistically non-significant.

2.3. Prediction of body weight from body measurements:

Raja *et al.* (2013) utilized the data on body weight and body measurements recorded of Attappady Black from its breeding tract. The whole data was classified into five age groups viz., 0-3, >3-6, >6-12, >12 and 0-12 months. The simple and multiple regression models were fitted with body weight as dependant variable and chest girth, body length and height at withers as independent variables. The correlation coefficients between body weights and body measurements at different ages were positive and strongly correlated ($P<0.01$) ranging from 0.509 to 0.915. The chest girth alone accounted for a maximum of 79.4 and 77.9 per cent of the total variation in body weight in males and females, respectively, signifying its importance for the prediction of body weight. Highest coefficient of determination (R^2- value) was obtained in the models when all the body measurements were included. These models also showed smaller RMSE and standard deviation ratio (SDR) thereby registering a better goodness of fit.

Ruhil *et. al.* (2013) developed artificial neural network models for prediction of body weight using different linear body measurement in

Attappady Black goats of Kerala, India. Data on body weight and body measurements were recorded on females goats. Data classified into 0-3, 3-6, 6-12 and 12 months. Three different morphometric measurement viz., chest girth, body length and height at withers were used as input variables and body weight was considered as output variable. Maximum prediction accuracy (77.19%) and minimum SD ratio (0.4838) was noticed for 0-3 months age groups and the RMSE was maximum for > 12 months age groups (2.72). The phenotypic correlations between actual and predicted body weights were positive, and highly significant ($P<0.01$) at all the age groups.

Tyagi *et. al*. (2013) studied a data of different age group, taken randomly of Surti goat under field conditions to determine the sex and age specific best fitted regression model for prediction of live weight. Seven prediction equations used in regression analysis involving all possible combination of body measurements and weight was regressed on body measurements. Based on R^2 values, sex dependent (S) regression equation were found to be better predictor of body weight in Surti kids. Equations were cross verified by comparing predicted, mean paired difference and range of paired difference at 95% confidence interval, age dependent (A) regression equations were found to be best fitted. Finally, 12 best fitted regression equations were obtained in which length-girth combination and girth alone were found to be better predictor of body weight. It was observed that R^2 alone not make a good indicator of prediction accuracy of the model and should be cross verified using other available statistical tools.

Chitra *et. al.* (2012) used a total of 152 adult female Malabari goats' body weight and body measurements (body length, height at withers and heart girth) to develop the step wise multiple regression equations. The average body weight, body length, height at withers and heart girth were 24.23 ± 0.73 kg, 59.42 ± 0.98 cm, 61.02 ± 1.03 cm and 66.54 ± 1.09 cm, respectively. The coefficient of determination was

lower in a regression model constructed by using height at withers (R^2=0.462) and body length (R^2=0.540), where as regression equation with heart girth was higher (R^2 = 0.709). Residual mean squares were found to be 15.341, 13.108 and 08.291 for height at withers, body length and heart girth, respectively. The coefficient of determination was recorded to be lower (R^2 =0.563) for body length and height at withers combination equation while that of prediction equations with heart girth as one of the independent variable noted to have higher R^2 value (0.719; 0.717 and 0.721). The residual mean square was found to be lower in the equations predicting with heart girth as one of the independent variable. Prediction of body weight based on heart girth alone or combined with other body measurements had higher coefficient of determination (R^2) and lower residual mean square (MSE).

Alex *et al*. (2010) used data on body weight and body measurements of Malabari goats, from farmers flock. The correlation between body weight and body measurements at different ages was positive and strongly correlated in most cases. Simple, multiple and curvilinear regression models were fitted with body weight as the dependent variable and body measurements as independent variables. Body measurements succeed to describe more variation in live weight. Separate prediction equations were made for females and males as well as for singles, twins, triplets and quadruplets. The coefficient of determination in different equations indicate that chest girth succeed in estimating body weight more than any other linear measurement and chest girth in combination with two or more measurement predict the body weight better. Following table explains the regression output including the best fitted function and coefficient of determination (adjusted R^2values).

Age	Group	Equation	Adjusted R^2
Below one month	Pooled	Y= -1.183+0.062X1+0.028X3+0.025X4	0.319
	Female	Y= -1.300+ 0.056 X3+ 0.063X1	0.364
	Male	Y= -0.822+ 0.067X1+ 0.035X4	0.277
	Singles	Y= -1.367+ 0.071X2+ 0.048X3	0.386
	Twins	Y= -0.747+0.057X4+0.042X2	0.259
	Triplets	Y= 0.399+ 0.064X3	0.237
	Quadruplets	Y= -1.224+0 .121X1	0.567
3 Months	Pooled	Y= -10.920+ 0.309X1+ 0.075X4+ 0.040X2	0.715
	Female	Y= -9.997+ 0.328X1+ 0.086X3	0.694
	Male	Y= -11.925+0.325X1+ 0.096X4+ 0.074X2+ -0.057X3	0.786
	Singles	Y= -9.626+ 0.347X1+ 0.056X4	0.660
	Twins	Y=-11.808+0.262X1+0.109X4+0.066X2	0.773
	Triplets	Y= -11.819+0.448X1	0.733
	Quadruplets	Y= -15.666+ 0.530X1	0.904
	Pooled	Y= -11.624+ 0.328X1+ 0.164X4	0.634
	Female	Y= -12.670+ 0.344X1+ 0.166X4	0.669

6 Months	Male	Y= -10.662+0 .285X1+ 0.189X4	0.603
	Singles	Y= -13.031+0.349X1+ 0.166X4	0.612
	Twins	Y= -8.436+ 0.280X1+ 0.156X4	0.632
	Triplets	Y= -12.985+ 0.512X1	0.734
	Quadruplets	Y= -10.500+ 0.500X2	1.000
9 Months	Pooled	Y= -19.164+0.485X1+0.153X4	0.648
	Female	Y= -15.116+0.567X1	0.626
	Male	Y= -25.238+ 0.429X1+ 0.305X4	0.621
	Singles	Y= -19.918+ 0.507X1+ 0.141X4	0.631
	Twins	Y= -15.114+0.573X1	0.661
	Triplets	Y= -7.342+ 0.409X2	0.733
12 Months	Pooled	Y= -14.751+0.311X1+ 0.132X2+0 .130X3	0.689
	Female	Y= -11.047+ 0.359X1+ 0.149X2	0.581
	Male	Y= -13.634+ 0.560X1	0.815
	Singles	Y= -14.770+0.301X1+ 0.160X2+0 .105X3	0.706

Y= body weight, X1=chest girth, X2= paunch girth, X3= body length and X4= height at wither, P=Pooled, F=Female, M=Male, S=Single, T=Twin, TR=Triplets, Q=Quadruplets

Faizur *et al*. (2007) studied the data to predict body weight from body measurements in goats. In group A, average live-weight. heart girth, body length and wither height at 12 months of age were 14.69 ± 0.62 kg, 55.63 ± 0.55 cm, 59.19 ± 1.46 cm and 45.49 ± 0.62 cm, respectively. In group B average age, live-weight, body measurements like heart girth, body length, wither height, with standard error were 9.21 ± 0.30 months, 13.29 ± 0.35 kg, 51.70 ± 0.55 cm, 49.50 ± 0.49 cm, 47.60 ± 0.47 cm, respectively. In group A at 12 months of age, highly significant correlations ($p < 0.01$) were found between live-weight with body length (0.92) and wither height (0.98). Correlation between live-weight with heart girth (0.76) was also significant ($p <0.01$). In group B at different ages highly positive significant correlations (0.73 to 0.86) were found between live weight and body measurements. The partial correlation between live weight and body measurements for constant age was 0.56 to 0.75. Body measurement expressed significant positive relationship with live weight for constant age. Simple linear regression and partial regression equation were used for estimation of live weight from body measurements of different groups with their reliability percentage. The existence of positive significant correlation of live weight with body measurements justified the use of linear regression for prediction of live weight. Body measurements can be separately or together used in estimating live weight in goats.

Moaeen-ud-Din *et al.* (2006) evaluated the fitness of two different formulae for estimation of weight and determination of the best fitted regression equation in Beetal, Teddi and Crossbred goats. Data on body weight and body measurements were collected of 100 each Beetal, Teddi and Crossbred animals. The correlation coefficients between body weights and body length + chest girth of Beetal goat were positively and significantly correlated (0.408 and 0.287) while non-significant with body height (0.091). The correlation coefficients for

different body measurements ranged between 0.578 to 0.900 and 0.318 to 0.376 for Teddi and Crossbred goats, respectively which were significantly correlated with body weight ($P<0.01$). Simple and multiple regression models were fitted with body weight as dependant variable and height at withers, chest girth and body length as independent variables. Total variation in body weight accounted by three body measurements in case of Beetal goat was 21.0 percent while 12.4 percent in case of crossbred animals. The model constructed with given data was the best fitted multiple regression model with chest girth, body length and height at wither as independent variables (R2 = 0.210, MSE = 19(18.032). This suggests that weight could be estimated more accurately by combination of two or more measurements.

Thiruvenkadan (2005) conducted a study on data of body weight and body measurements of Kanni Adu kids (114 males and 214 females) from its breeding tract. Simple and multiple regression models were fitted with body weight as dependant variable and height at withers, chest girth and body length as independent variables. The coefficient of determination indicated that body measurements succeed to describe more variation in live weight. The chest girth accounted maximum of 80.4 to 93.6 per cent of total variation in body weight. The model constructed with pooled data from birth to 12 months of age was the best fitted multiple regression models with chest girth, body length and height at withers as an independent variables (R^2 = 0.913, MS_E = 1.82 for males and R^2 = 0.948, MS_E = 1.195 for females). In all age groups the highest R^2 obtained, if include all the body measurements in the regression equation. This indicates that weight could be estimated more accurately by combination of two or more measurements. However, a study of different criteria revealed that model having a larger R^2 with a smaller MS_E and SD_E produced a better goodness of fit. The correlation coefficients between body weights and body measurements at different ages were positive and strongly correlated

(P<0.01). The correlation coefficient for different body measurements ranged between 0.506 and 0.968.

Suranagi *et. al.* (2005) recorded biometrical observations on 53 Bidri goats in and around Bidar taluka of Karnataka. The measurements recorded on body length (point of shoulder to pin bone), chest girth (circumference immediately behind the forelimbs) and height (ground level to wither). Live body weight was also recorded on adult normal Bidri goats. The correlation coefficients between various biometrical measures were highly significant (P< 0.01). For estimating the body weight the prediction equation was developed. From the estimates it is seen that the index of R^2 for maximum chest girth is higher than the others. This means that a given ratio of increase in girth counts more for weight than the corresponding increase in length and/or height.

4. RESULTS AND DISCUSSION

The results for growth, production, reproduction performance and factors affecting it have been presented and discussed under the following headings:

4.1 Body weight at different ages (*viz.* birth, 3 months, 6 months, 9 months and 12 months).
4.2 Genetic and non-genetic factors affecting the body weight at different ages.
4.3 Genetic and phenotypic parameters for body weight at different ages.
4.4 Morphometric traits at different ages (*viz.* birth, 3 months, 6 months, 9 months and 12 months)
4.5 Genetic and non-genetic factors affecting morphometric traits at different ages.
4.6 Genetic and phenotypic parameters for morphometric traits at different ages.
4.7 Production performance and factors affecting it.
4.8 Reproduction performance and factors affecting it.
4.9 Prediction equation of body weight from body measurements.

4.1 Body weight at different ages

The estimates of overall least-squares means at birth, 3, 6, 9 and 12 months of ages are given in Table 4.2.

The overall least-squares mean of birth weight was estimated as 2.55 ± 0.05 kg. The present finding is in close agreement with the reports of Singh *et al.* (2002) as 2.54±0.04 kg in Beetal and Bhusan and Rai (2007) as 2.521 kg in Jakhrana kids. The lower estimates of 1.75 ± 0.07 kg in Black Bengal by Singh *et al.* (2002), 1.88 ± 0.57 kg in Barbari by Bharathidhasan *et al.* (2009), 2.35 ± 0.04 in Sirohi by Meel

et al. (2010), 1.85 ± 0.02 kg in Osmanabadi Birari *et al.* (2012), 1.838 ± 0.02 kg in Surti kids by Tyagi *et al.* (2013) and 2.10 ± 0.06 kg in Sirohi by Bhakar (2014) for birth weight was reported. However, higher estimates of birth weight as 2.88 ± 0.03 kg by Mehta *et al.* (1997), 2.84 ± 0.07 kg by Tomar *et al.* (2004), 2.89 ± 0.01 kg by Arora *et al.* (2011), 3.11 ± 0.01 kg by Gowane *et al.* (2011a) in Sirohi goats and 2.43± 0.04 kg in Berari kids by Kharkar *et al*. (2014) was reported.

The average of 3 months body weight was estimated as 13.30 ± 0.47 kg. The present finding was in close agreement with the reports of Bhakar (2014) as 13.29 ± 0.428 kg in Sirohi goats. The lower estimates of 10.94 ± 0.10 kg by Pathodiya *et al.* (2003), 10.71 ± 0.33 kg by Tomar *et al.* (2004), 10.84 ± 0.23 kg Sharma *et al.* (2010) and 11.37 ± 0.09 kg by Arora *et al.* (2011) was reported in Sirohi kids. However, higher estimates of three months body weight as 13.64 ± 0.11 kg in Beetal kids by Alam *et al.* (2007) and 14.47 ± 0.57 kg in Sangamneri goats by Verma *et al.* (2010) were reported.

The average 6 months body weight was estimated as 16.96 ± 0.52 kg. The present finding is in close agreement with the reports of Bhakar (2014) as 16.94 ± 0.650 kg in Sirohi goats. The lower estimates of 15.82 ± 0.14 kg by Pathodiya *et al.,* (2003), 15.76 ± 0.15 kg by Pathodiya *et al.,* (2004), 15.33 ± 0.50 kg by Tomar *et al.,* (2004), 15.24 ± 0.24 kg by Sharma and Pathodiya (2007) and 16.31±0.21 kg by Meel *et al.,* (2010) were reported in Sirohi kids. Whereas, higher 6 months body weight was recorded by Mehta *et al.* (1997) as 19.29 ± 0.22 kg and Gowane *et al.* (2011a) as 18.36 ± 0.09 kg in Sirohi kids, however in other breeds 18.80 ± 1.92 kg in Jamunapari goats by Patel *et al.* (2005), 19.40 ± 0.44 kg in Beetal goats by Alam *et al.* (2007) and 20.26 ± 0.83 kg in Sangamneri goats by Verma *et al.* (2010) were reported.

The overall least-squares mean for 9 months body weight was estimated as 20.98 ± 1.05 kg, which was similar with the reports of Patel *et al.* (2005) as 20.92±1.44 kg in Jamunapari goats. The lower estimates of 19.42 ± 0.24 kg by Pathodiya *et al.* (2003), 18.65 ± 0.37

kg by Pathodiya (2004), 18.33 ± 0.44 kg by Sharma and Pathodiya (2007), 19.34 ± 0.25 kg by Meel *et al.* (2010) and 20.00 ± 0.868 kg by Bhakar (2014) in Sirohi goats were reported**.** However, slightly higher 9 months body weight as 22.01 ± 0.33 kg by Mehta *et al.* (1997) and 22.02 ± 0.10 kg by Gowane *et al.* (2011a) were recorded in Sirohi goats.

The average 12 months body weight was estimated as 25.80 ± 0.49 kg. Similar estimate of 25.80±0.12 kg was reported by Gowane *et al.* (2011a) in Sirohi goats. The lower estimates of 23.73±0.25 kg by Pathodiya *et al.* (2003), 21.94 ± 0.35 kg by Sharma and Pathodiya (2007), 23.27±0.36 kg by Meel *et al.* (2010), 24.45 ± 0.22 kg by Arora *et al.* (2011) and 24.87 ± 1.105 kg by Bhakar (2014) were reported in Sirohi goats**.** However, higher 12 months body weight as 26.28 ± 1.23 kg in Kuchi goats by Kumar *et al.* (2006) and 27.28 ± 0.38 kg in Beetal goats by Alam *et al.* (2007) were reported.

4.2 Genetic and non-genetic factors affecting the body weight at different ages

The results regarding effect of genetic and non-genetic factors on body weight at different ages in present study are given in Table 4.1 and 4.2.

4.2.1 Effect of sire

Highly significant effect of sire (P≤ 0.01) was observed on body weight at birth, 3, 6, 9 and 12 months of ages. Similar results were observed by Roy *et al.* (1997) in Jamunapari goats, Yadav *et al.* (2003) in Kutchi goats, Rai *et al.* (2004) except on 12 months of age in Marwari goats, Sharma (2005) and Bhakar (2014) in Sirohi goats. Significant effect of sire (P≤ 0.05) at birth was reported by Karna *et al.* (2001) in Chegu, Pathodiya *et al.* (2004) in Sirohi and Afzal *et al.* (2004) in Beetal goats. However, non-significant effect of sire was reported by Kumar *et al.* (1992) on birth, 9 and 12 months body

weights in Jamunapari and Yadav *et al.* (2013) on 12 months body weights in Kutchi goats.

This indicates that sire contributes significantly in the variability of growth traits, superior sire could be used effectively for further improvement of body weight at different ages in farmer's flock. Hence while redistribution of sires in farmer's flock inferior sires should be culled on the basis of progeny proofs.

4.2.2 Effect of cluster

Effect of cluster was highly significant (P≤ 0.01) on birth, 3, 6, 9 and 12 months body weights (Figure 1-5). This finding is in close agreement with the reports of Kuthu *et al.* (2013) in Teddy goats and Bhakar (2014) in Sirohi goats. Similar observations were reported by Joshi (1991), Sharma (1994) and Gokhale *et al.* (1996) on birth, 3 and 6 months body weights. Sharma *et al.* (2010) on birth and 3 months body weights in Sirohi, Birari *et al.* (2012) on birth, 3, 6 and 12 months body weight in Osmanabadi goats and Tyagi *et al.* (2013) on birth, 3, 6, 9 and 12 months body weights in Surti goats. However, non-significant effect of cluster on 3, 9 and 12 months body weights was reported by Patil *et al.* (2013) in Sangamneri goats and Kharkar *et al*. (2014) on birth and 3 months body weights in Berari goats.

The body weight was significantly affected by the cluster (P≤0.01) at all ages which may be attributed to difference in management practices between clusters. Significantly (P≤0.01) higher mean body weight was observed in Bhadsoda cluster as compared with remaining four clusters in all age groups. The mean body weight at 6 months and 9 months of age in Devgarh cluster were higher and comparable with Railmagra cluster however kids of Bhadsoda cluster remained at top in terms of mean body weight. Kids of Railmagra cluster had second highest mean body weight followed by Bhadsoda cluster at 12 months of age.

4.2.3 Effect of Season of birth

Season of birth had non-significant effect on birth and 6 months body weight. Singh and Khan (2002) in Jakhrana goats, Thiruvenkadan *et al.* (2009) in Tellicherry goats, Sharma *et al.* (2010) in Sirohi, Bhusan (2012) in Jakhrana, Kharkar *et al.* (2014) and Bhakar (2014) also reported non-significant effect of season of birth on birth weight. Most of the authors revealed significant effect of season of birth on birth weight as Pathodiya *et al.* (2003) in Sirohi goats, Kumar *et al.* (2007) in Kuchi goats, Singh *et al.* (2009) in Jamunapari, Mandal *et al.* (2010) in Jakhrana, Meel *et al.* (2010) and Arora *et al.* (2011) in Sirohi and Yadav *et al.* (2013) in Kutchi goats.

The season of birth had highly significant (P≤ 0.01) effect on 3 and 9 months body weights and significant (P≤ 0.05) effect on 12 months body weight (Figure 2, 4 and 5). Similar findings were also reported by Yadav *et al.* (2008) in Kutchi, Singh *et al.* (2009) in Jamunapari, Thiruvenkadan *et al.* (2009) in Tellicherry goats, Meel *et al.* (2010), Arora *et al.* (2011) and Bhakar (2014) in Sirohi goats at 3, 6, 9 and 12 months body weights. Non-significant effect of season of birth was reported by Pathodiya (2004) on 6, 9 and 12 months body weights and Meel *et al.* (2010) on 12 months body weight in Sirohi goats, Bhusan (2012) on 3, 6 and 9 months body weights in Jakhrana goats and Yadav *et al.* (2013) on 12 months body weight in Kutchi goats.

Most of the does had kidding during winter (48.53%) followed by rainy (36.69%) season while there was less frequency of kidding during summer (14.78 %) season. At 3 months of age body weight was significantly higher in winter born kid. They grew faster than kids born in other seasons. This might be due to the better health and nutrition of their dam which they got during rainy season in their pregnancy and nourished their young ones well. After three months of age maternal effect is reduced and growth of kid depends on availability of grazing material to them and their own fitness. The growth of kids at 9 months

of age was significantly faster in kids born during rainy season as compared to those born in winter and summer months.

4.2.4 Effect of Year of birth

The year wise variation at birth, 3, 6, 9 and 12 months body weight was highly significant (P≤ 0.01) (Figure 1-5). This finding is in close agreement with the reports of Bhakar (2014) in Sirohi goats. Similar observations were reported by Kuralker *et al.* (2002) at birth, 3 and 6 months of body weight, Pathodiya (2004), Meel *et al.* (2010) at birth, 3, 6, 9 and 12 months body weight and Sharma *et al.* (2010) at birth and 3 months body weight in Sirohi goats, Rout *et al.* (2002) at all ages body weight in Jamunapari goats, Mandal *et al.* (2010) for body weight at 3, 6, 9 and 12 months of ages and Bhusan (2012) for body weight at birth, 3, 6, 9 and 12 months of ages in Jakhrana goats and Yadav *et al.* (2013) for body weight at birth, 3, 6 and 9 months of age in Kutchi goats. However, non-significant effects of year of birth were reported by Pathodiya *et al.* (2003) on body weight at 12 months of age in Sirohi, Yadav *et al.* (2003) on body weight at 3, 6, 9 and 12 months of age, Rai *et al.* (2004) on body weight at 6, 9 and 12 months of ages in Marwari, Mandal *et al.* (2010) on birth weight in Jakhrana goats, Kumar *et al.* (2011) on birth, 3 and 12 months of age in Black Bengal goats and Jagdale *et al.* (2012) on body weight at 3 and 6 months of ages in Sangamneri goats and Yadav *et al.* (2013) on body weight at 12 months in Kutchi goats.

Growth pattern of Sirohi goats under this investigation was estimated higher birth weight of kids for those born in initial two years and declined in next year with gradually increasing up to last year thereafter. The differences in feeding, management and breeding practices adopted by breeders for pregnant does and across scarcity/drought periods may leads to such variations. Significant effect of year of birth on the body weight at different ages might also be due to use of sires with varying breeding value. The changes in breeding

buck's management and environmental condition may leads to overall changes in growth performance over the years.

4.2.5 Effect of parity of dam

The effect of parity on body weights of kids at all ages was non-significant. Incidentally the kids born in fifth parity had minimum weights after three months of age but birth and 3 months body weight was highest. Kids born in first parity had minimum weight at birth and 3 months of age and minimum weight at 6, 9 and 12 months of ages were reported in fifth parity but difference was statistically non-significant. However relationship of weight at early ages may affect later ages but it is not seen through parity effects. It may also be related to differential culling rates of kids at different ages born from different parities.

Non-significant effect of parity of dam on body weights of kids was estimated by Joshi (1991) at birth, 3, 6 and 12 months of age, Pathodiya (2004) at 6, 9 and 12 months of age, Kumar *et al.* (2005) in Tellicherry goats and Mandal *et al.* (2010) at 6, 9 and 12 months of age in Jakharana goats. Highly significant effect (P≤ 0.01) at birth, 3 and 6 months of age and non-significant at 9 and 12 months of age was reported by Pathodiya *et al.* (2003) in Sirohi goats.

4.2.6 Effect of type of birth

Effect type of birth was highly significant (P≤ 0.01) on body weight at birth, 3, 6, 9 and 12 months of age (Figure 1-5). The results were in close agreement with findings of Mehta *et al.* (1997), Meel *et al.* (2010), Arora *et al.* (2011), Bhakar *et al.* (2014) on body weight at all stages from birth to 12 months of age in Sirohi goats, Thiruvenkadan *et al.* (2009) in Tellicherry goats and Singh et al. (2009) in Jamunapari goats from birth to 12 months of age, Kumar *et al.* (2011) on body weight at birth, 3, 6 and 12 months of ages in Black Bengal goats and Yadav *et al.* (2013) on body weight at birth, 3, 6 and 9 months of ages

in Kutchi goats. While non-significant effect of type of birth was observed by Rai *et al.* (2004) on 9 and 12 months body weights in Marwari, Kumar *et al.* (2005) on birth and 3 months body weights in Tellicherry, Yadav *et al.* (2008) on 6, 9 and 12 months body weights in Kutchi, Mandal *et al.* (2010) and Bhusan (2012) on 3, 9 and 12 months body weights in Jakhrana goats.

Kids born as single were heavier in body weight in comparison to those born as multiple, this might be due to higher availability of nutrients, physiological limitation of uterine environment and space during pre-natal period.

4.2.7 Effect of sex of kid

The effect of sex on body weights was observed as highly significant (P≤ 0.01) at birth, 3, 6, 9 and 12 months of age (Figure 1-5). Similar results were reported by Mehta *et al.* (1997), Meel *et al.* (2010) and Arora *et al.* (2011) on body weights at all age in Sirohi goats, Rai et al. (2004) at birth, 3, 6, 9 and 12 months of age in Marwari goats, Rout *et al.* (2002), Singh *et al.* (2009) and Singh *et al.* (2013) at birth, 3, 6, 9 and 12 months of age in Jamunapari goats, Birari *et al.* (2012) on body weights at birth, 3, 6 and 12 months of age in Osmanabadi. On the contrary, Pathodiya *et al.* (2003) on 6, 9 and 12 months body weights and Sharma *et al.* (2010) on 3 months body weight in Sirohi, Mandal *et al.* (2010) at birth to 12 months of age in Jakhrana goats. Kumar *et al.* (2011) on birth and 3 months body weights in Black Bengal and Tyagi *et al.* (2013) on 12 months body weight in Surti goats reported non-significant effect of sex of kid.

This was mainly due to the anabolic effect of androgen which enhances the growth in males (Hafez, 1962) or some other growth factors related to Y chromosome.

4.2.8 Effect of Dam's weight at kidding

The effect of dam's weight at kidding was positive and highly significant (P≤ 0.01) on the birth and 3 months body weights of age of its kids. These results were in agreement with the findings of Mehta *et*

al. (1997), Arora *et al.* (2011) and Bhakar (2014) for birth and 3 months body weights in Sirohi. Khan and Sahani (1983), Roy *et al*. (1989), Rout *et al.* (2002), Singh *et al*. (2009) Singh *et al*. (2013) in Jamunapari goats and Yadav *et al.* (2013) in Kutchi goats for birth and 3 months body weights. On the contrary non-significant effect of dam's weight at kidding on body weights of kids was revealed by Yadav *et al.* (2008) at birth in Kutchi and Sharma *et al.* (2010) at 3 months of age in Sirohi kids.

Positive but non-significant effect of regression of dam's weight at kidding on body weights of kids at six and nine months of ages was observed. Similar results were estimated by Bhakar (2014) in Sirohi goats. Yadav *et al.* (2003) for 6 and 9 months body weights in Kutchi and Kumar *et al.* (2005) for 6 months body weight in Tellicherry goats were observed similar results. However, significant effect was observed by Mehta *et al.* (1997) and Arora *et al.* (2011) on 6 and 9 months body weights in Sirohi goats, where as Rout *et al.* (2002), Singh *et al.* (2009) and Singh *et al.* (2013) in Jamunapari goats.

Positive and significant ($P \leq 0.05$) effect of regression of dam's weight at kidding was observed on 12 months weight of its kids. These findings were supported by Mehta *et al.* (1997) and Arora *et al.* (2011) in Sirohi and Singh *et al.* (2013) in Jamunapari goats. On the other hand Roy *et al.* (1989) in Jamunapari and Yadav *et al.* (2003) in Kutchi goats reported this as a non-significant effect on 12 months body weight.

Results suggested that the heavy pregnant dams delivered heavier kids. Heavier kids at birth had better growth during subsequent stages. The heavier dams provided better nourishment and more space for developing fetus resulting in heavier weights at birth and subsequent ages.

Table 4.1 Least squares analysis of variance for various factors affecting body weights in Sirohi goats

SOURCE OF VARIATION	BWT		3WT		6WT		9WT		12WT	
	D.F	M.S.	D.F	M.S.	D.F	M.S.	D.F	M.S.	D.F	M.S.
Sire	58	0.98 **	54	35.19**	52	31.56**	49	36.92**	48	32.78**
Cluster	4	4.93 **	4	167.82**	4	302.94**	4	266.81**	4	282.15**
Season	2	0.32	2	82.56 **	2	4.20	2	81.40**	2	34.66*
Year	5	1.97 **	5	52.63**	6	88.10**	5	156.03**	5	176.78**
Parity	4	0.25	4	0.70	4	5.27	4	7.09	4	6.41
Type of birth	1	402.11**	1	1034.3**	1	859.58**	1	461.94**	1	428.41**
Sex	1	47.66**	1	1234.3**	1	1254.8**	1	1452.59**	1	1421.53**
Reg. on DWK	1	1.54 **	1	21.77**	1	2.50	1	26.90	1	42.64*
Error	3474	0.177265	3000	3.112167	2123	4.589295	1574	6.628873	1079	8.911424

Note : BWT= Birth weight, 3WT= 3 months body weight, 6WT= 6 months body weight, 9 WT= 9 months body weight, 12 WT= 12 months body weight. D.F. =Degree of freedom, M. S. = Mean squares, Reg. on DWK = Regression on weight of dam at kidding ** = Highly significant (P≤0.01), *= Significant (P≤0.05)

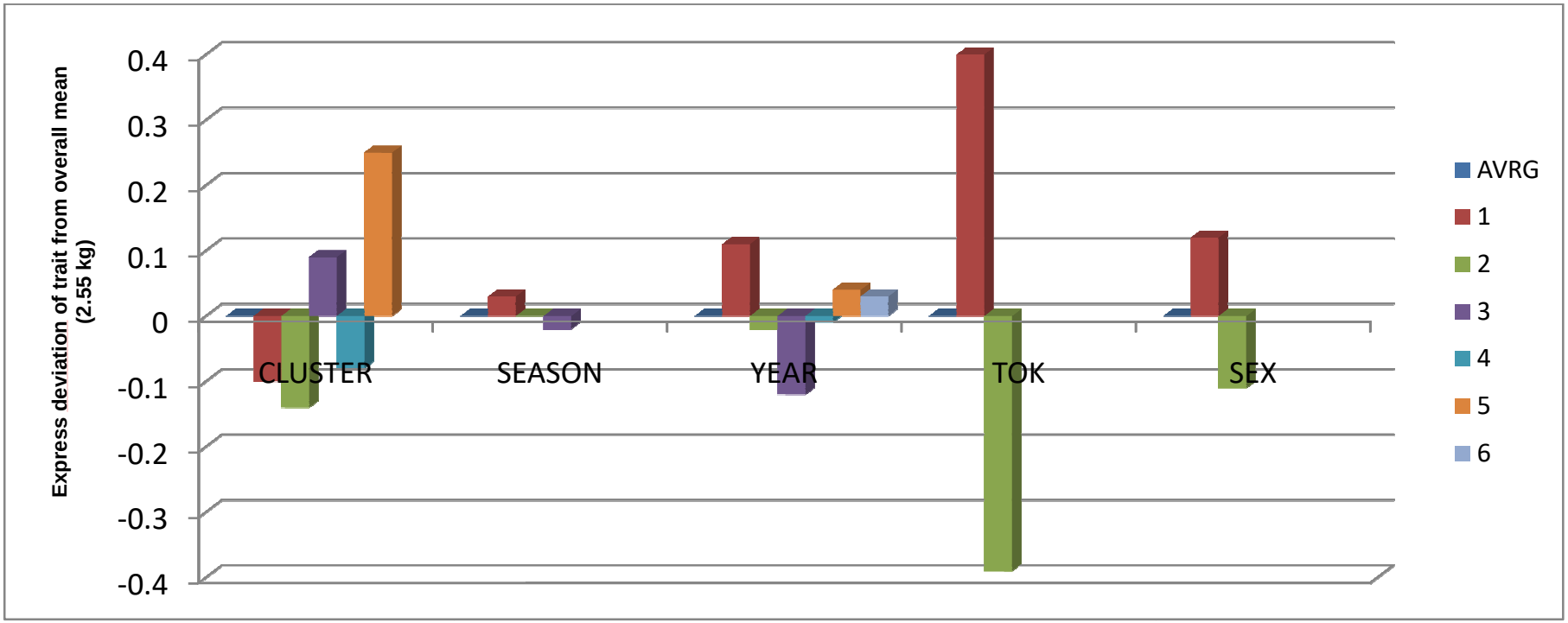
Table No. 4.2. Least-squares means and S.E. for body weights (kg) of Sirohi goat at different ages

Traits / Factors	At birth	3 month	6 month	9 month	12 month
Overall mean (μ)	2.55 ± 0.05 (3551)	13.30 ± 0.47 (3073)	16.96 ± 0.52 (2194)	20.98 ± 1.05 (1642)	25.80 ± 0.49 (1144)
Sire	**	**	**	**	**
Cluster	**	**	**	**	**
Vallabhnagar	2.45 ± 0.06^{a} (278)	11.42 ± 0.51^{a} (214)	14.71 ± 0.60^{a} (123)	19.15 ± 1.12^{a} (59)	19.93 ± 1.35^{a} (36)
Railmagra	2.41 ± 0.06^{a} (650)	13.22 ± 0.50^{b} (593)	16.99 ± 0.58^{b} (504)	20.61 ± 1.09^{b} (396)	26.33 ± 0.71^{c} (229)
Devgarh	2.64 ± 0.06^{b} (1584)	13.56 ± 0.50^{c} (1439)	17.71 ± 0.58^{c} (1184)	21.68 ± 1.09^{c} (943)	25.04 ± 0.73^{b} (715)
Nathdwara	2.47 ± 0.14^{a} (37)	13.33 ± 0.85^{bc} (15)	14.33 ± 1.11^{a} (12)	17.14 ± 1.95^{a} (3)	---
Bhadsoda	2.80 ± 0.06^{bc} (1002)	15.00 ± 0.50^{d} (812)	21.05 ± 0.59^{d} (371)	26.30 ± 1.10^{d} (241)	31.90 ± 0.80^{d} (164)
Season	NS	**	NS	**	*
Rainy	2.58 ± 0.05 (1303)	13.08 ± 0.47^{a} (1171)	16.95 ± 0.52 (795)	21.50 ± 1.06^{b} (507)	25.89 ± 0.50^{b} (377)
Winter	2.55 ± 0.05 (1723)	13.63 ± 0.47^{b} (1443)	17.06 ± 0.53 (1021)	20.92 ± 1.06^{a} (829)	25.42 ± 0.50^{a} (589)
Summer	2.53 ± 0.06 (525)	13.20 ± 0.48^{a} (459)	16.87 ± 0.53 (378)	20.51 ± 1.06^{ab} (306)	26.09 ± 0.53^{b} (178)
Year of birth	**	**	**	**	**
2007-08	2.66 ± 0.06^{d} (491)	12.83 ± 0.50^{a} (453)	16.01 ± 0.56^{b} (404)	19.78 ± 1.09^{b} (350)	25.01 ± 0.62^{a} (310)
2008-09	2.53 ± 0.06^{b} (586)	12.77 ± 0.50^{a} (530)	15.60 ± 0.56^{a} (412)	19.24 ± 1.09^{a} (316)	25.10±0.61^{be} (209)
2009-10	2.43 ± 0.05^{a} (624)	12.88 ± 0.48^{a} (525)	16.61 ± 0.53^{c} (394)	19.83 ± 1.06^{b} (320)	24.50 ± 0.56^{a} (186)
2010-2011	2.54 ± 0.06^{bc} (531)	13.40 ± 0.49^{b} (467)	17.25 ± 0.54^{d} (376)	21.28 ± 1.07^{c} (308)	26.23 ± 0.60^{c} (218)
2011-2012	2.59 ± 0.05^{dc} (668)	14.06 ± 0.48^{c} (570)	18.27 ± 0.54^{e} (406)	22.69 ± 1.07^{d} (301)	28.16 ± 0.60^{d} (221)
2012-2013	2.58 ± 0.06^{c} (651)	13.88 ± 0.49^{c} (528)	18.02 ± 0.56^{e} (202)	23.04 ± 1.15^{d} (47)	---
Parity	NS	NS	NS	NS	NS
1st	2.52 ± 0.06 (779)	13.24 ± 0.48 (664)	16.89 ±0.53 (507)	20.91 ± 1.07 (393)	25.88 ±0.54 (276)
2nd	2.57 ± 0.06 (678)	13.30 ± 0.48 (589)	17.11 ±0.53 (455)	21.02 ± 1.06 (348)	26.01 ±0.52 (243)
3rd	2.56 ± 0.06 (610)	13.34 ± 0.48 (553)	16.94 ±0.53 (411)	21.14 ± 1.06 (303)	25.94 ±0.52 (220)
4th	2.55 ± 0.05 (530)	13.31 ± 0.47 (461)	17.03 ±0.54 (317)	21.07 ± 1.07 (218)	25.60± 0.54 (152)
≥ 5th	2.58 ± 0.05 (954)	13.34 ± 0.47 (806)	16.82 ±0.53 (504)	20.74 ± 1.06 (380)	25.58 ±0.52 (253)
Type of birth	**	**	**	**	**
Single	2.95 ± 0.05^{b} (2080)	13.99 ± 0.47^{b} (1842)	17.71 ±0.52^{b} (1386)	21.62 ± 1.05^{b} (1049)	26.55 ±0.49^{b} (752)
Multiple	2.16 ± 0.05^{a} (1471)	12.62 ± 0.47^{a} (1231)	16.20 ±0.53^{a} (808)	20.33 ± 1.06^{a} (593)	25.05 ±0.50^{a} (392)

Sex	**	**	**	**	**
Male	2.67 ± 0.05[b] (1768)	13.95 ± 0.47[b] (1536)	17.73 ±0.52[b] (1023)	21.97 ± 1.06[b] (679)	27.05 ±0.51[b] (372)
Female	2.44 ± 0.05[a] (1783)	12.66 ± 0.47[a] (1537)	16.18 ±0.52[a] (1171)	19.98 ± 1.05[a] (963)	24.55 ±0.49[a] (772)
Regression on weight of dam at kidding	**	**	NS	NS	*
Regression coefficient (b) (kg/kg)	0.011±0.004	0.048±0.02	0.02±0.027	0.004±0.037	0.116±0.053

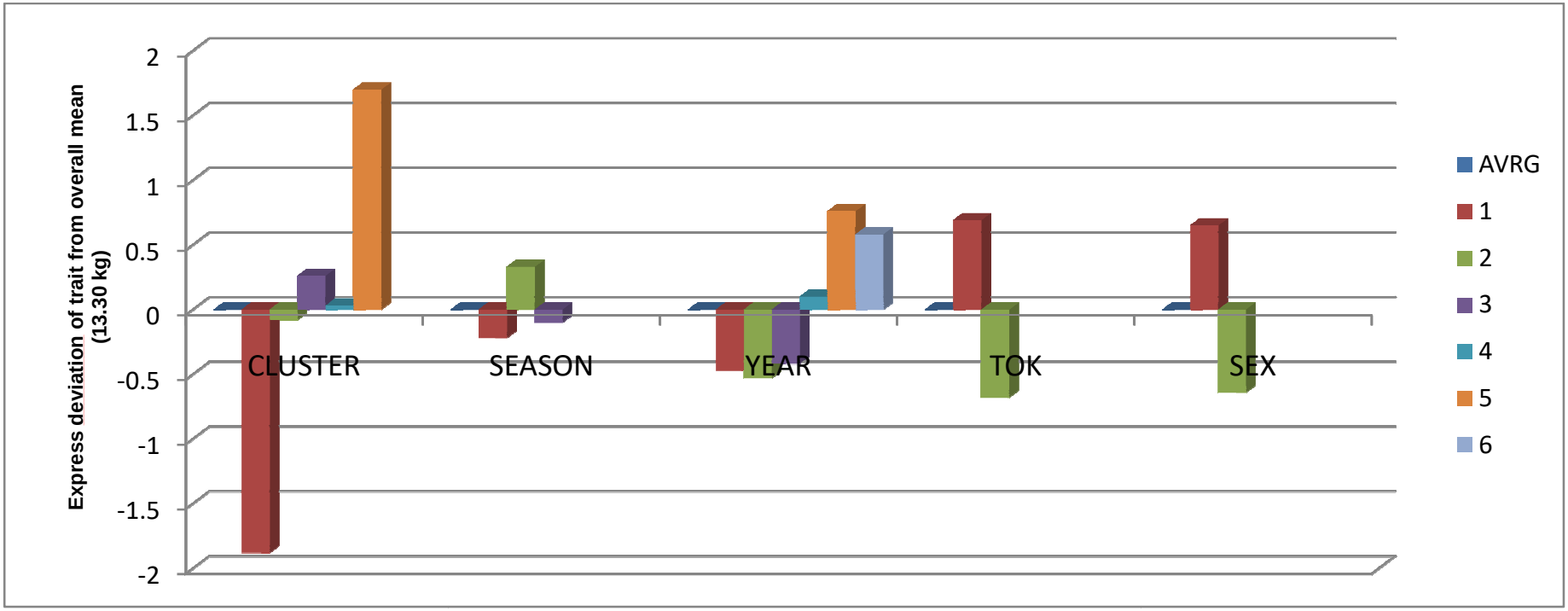
NOTE: No. Of observations are given in parentheses. Estimates with different superscripts differ significantly. ** = Highly significant (P≤0.01), * = Significant (P≤0.05), NS = Non-significant.

Figure 1. Factors affecting birth weight of Sirohi goats



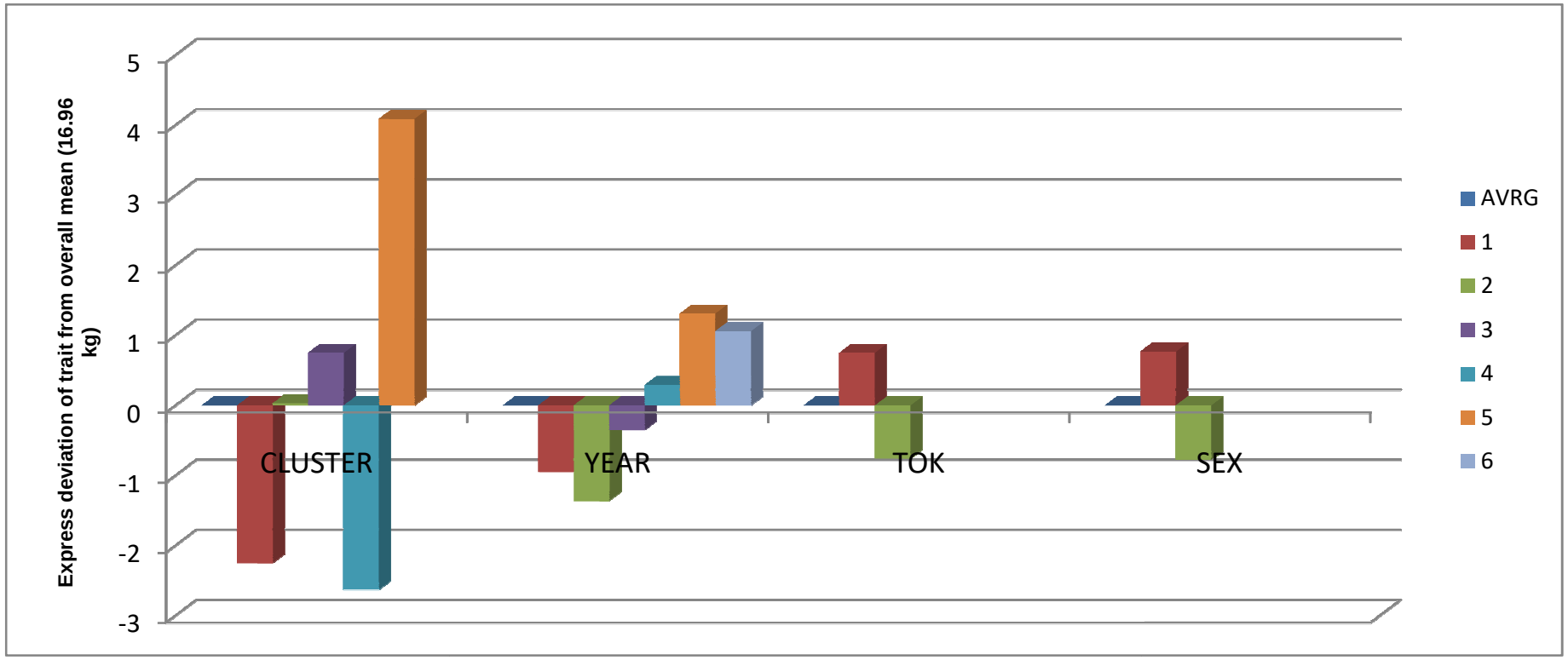
Cluster- 1 to 5 (Vallabhnagar, Railmagra, Devgarh, Nathdwara and Bhadsoda); **Season-** 1 to 3 (Rainy, Winter and Summer); **Year-** 1 to 6 (2007-08, 2008-09, 2009-10, 2010-11, 2011-12 and 2012-13); **Type of kidding-** 1 and 2 (Single and Multiple); **Sex-** 1 and 2 (Male and Female).

Figure 2. Factors affecting 3 months body weight of Sirohi goats



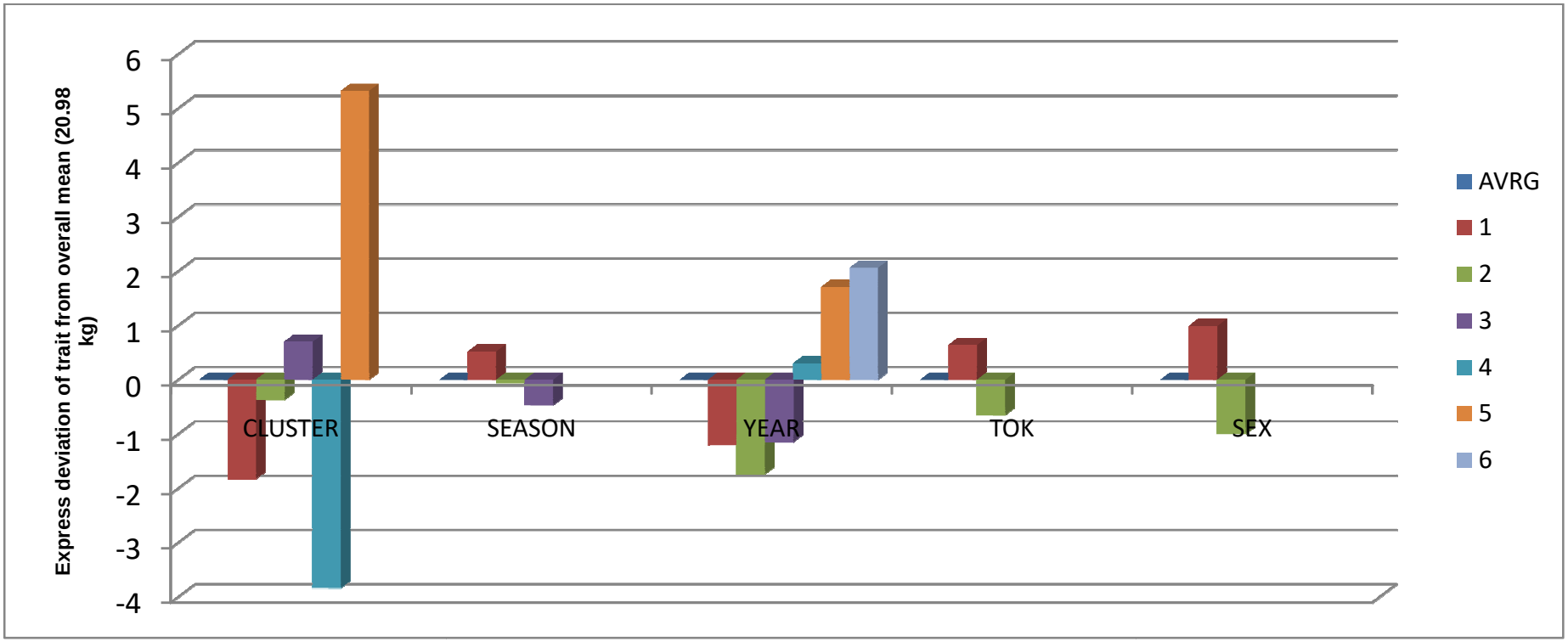
Cluster- 1 to 5 (Vallabhnagar, Railmagra, Devgarh, Nathdwara and Bhadsoda); **Season-** 1 to 3 (Rainy, Winter and Summer); **Year-** 1 to 6 (2007-08, 2008-09, 2009-10, 2010-11, 2011-12 and 2012-13); **Type of kidding-** 1 and 2 (Single and Multiple); **Sex-** 1 and 2 (Male and Female).

Figure 3. Factors affecting 6 months body weight of Sirohi goats



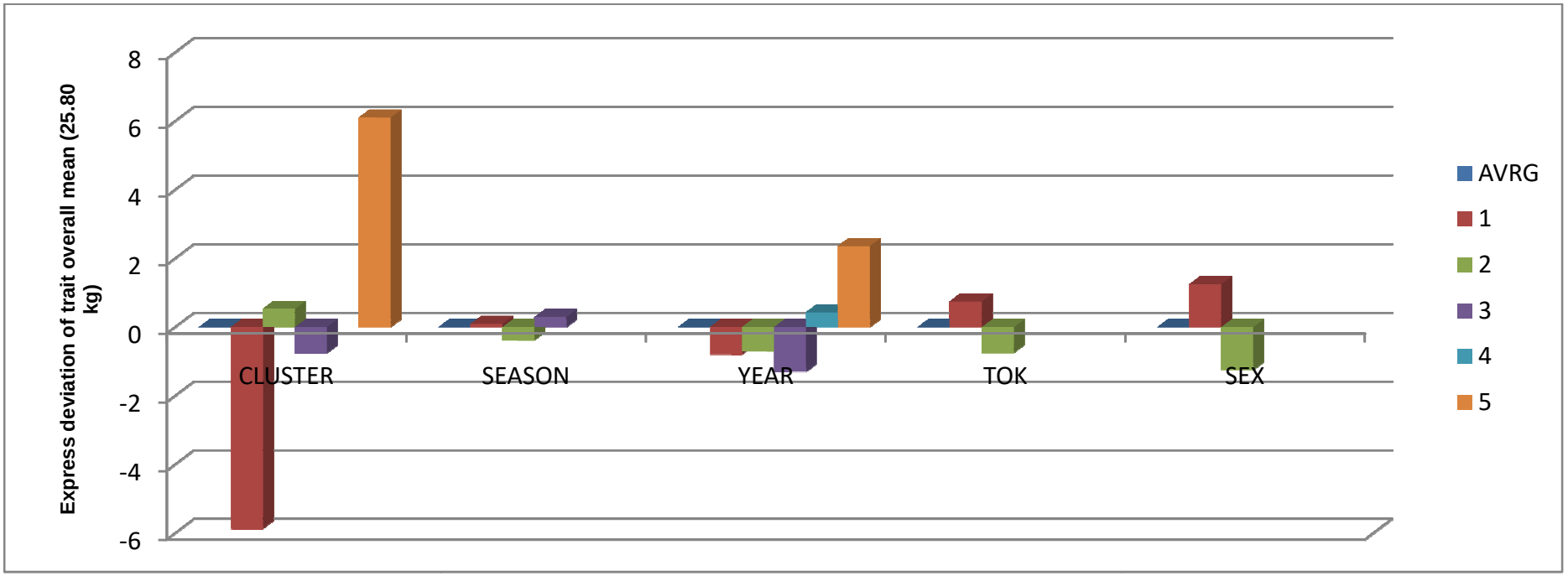
Cluster- 1 to 5 (Vallabhnagar, Railmagra, Devgarh, Nathdwara and Bhadsoda); **Season-** 1 to 3 (Rainy, Winter and Summer); **Year-** 1 to 6 (2007-08, 2008-09, 2009-10, 2010-11, 2011-12 and 2012-13); **Type of kidding-** 1 and 2 (Single and Multiple); **Sex-** 1 and 2 (Male and Female).

Figure 4. Factors affecting 9 months body weight of Sirohi goats



Cluster- 1 to 5 (Vallabhnagar, Railmagra, Devgarh, Nathdwara and Bhadsoda); **Season-** 1 to 3 (Rainy, Winter and Summer); **Year-** 1 to 6 (2007-08, 2008-09, 2009-10, 2010-11, 2011-12 and 2012-13); **Type of kidding-** 1 and 2 (Single and Multiple); **Sex-** 1 and 2 (Male and Female).

Figure 5. Factors affecting 12 months body weight of Sirohi goats



Cluster- 1 to 5 (Vallabhnagar, Railmagra, Devgarh, Nathdwara and Bhadsoda); **Season-** 1 to 3 (Rainy, Winter and Summer); **Year-** 1 to 6 (2007-08, 2008-09, 2009-10, 2010-11, 2011-12 and 2012-13); **Type of kidding-** 1 and 2 (Single and Multiple); **Sex-** 1 and 2 (Male and Female).

4.3 Genetic and phenotypic parameters for body weight at different ages

The results regarding estimated genetic and phenotypic parameters *viz*. heritability, genetic and phenotypic correlation are presented in Table 4.3.

Table 4.3: Estimates of heritability (on diagonal), genetic correlation (above diagonal) and phenotypic correlation (below diagonal) among body weights at different ages in Sirohi goats.

Trait	BWT	3 WT	6WT	9WT	12WT
BWT	**0.318 ± 0.063**	0.391 ± 0.151	0.301 ± 0.301	0.245 ± 0.175	0.449 ± 0 .158
3 WT	0.251 ± 0.027	**0.693 ± 0.115**	0.864 ± 0.052	0.772 ± 0.085	0.899 ± 0.063
6 WT	0.172 ± 0.028	0.623 ± 0.018	**0.563 ± 0.105**	0.926 ± 0.038	0.891 ± 0.059
9 WT	0.161 ± 0.028	0.447 ± 0.023	0.685 ± 0.015	**0.560 ± 0.112**	0.890 ± 0.053
12 WT	0.181 ± 0.028	0.387 ± 0.025	0.510 ± 0.021	0.680 ± 0.015	**0.475 ± 0.111**

Note: BWT= Birth weight, 3WT= 3 months body weight, 6WT= 6 months body weight, 9 WT= 9 months body weight, 12 WT= 12 months body weight; Phenotypic correlations are highly significant tested by't' test.

4.3.1 Heritability

The effect of sire was significant on body weight at all ages revealed by ANOVA given in Table 4.1. The heritability estimates of different traits were estimated from sire component of variance by paternal half sib relationship in Table 4.3. The estimates are discussed as follows.

The heritability of birth weight (BWT) in the present study was estimated as 0.318 ± 0.063. Lower estimates were reported by Mehta *et al.* (1997) as 0.14 ± 0.15, Shinde *et al.* (2002) as 0.152 ± 0.025 and Tomar *et al.* (2004) as 0.26 ± 0.21 in Sirohi goats. Higher estimates were reported by Roy *et al.* (1989) as 0.463 ± 0.148, Singh *et al.* (2000) as 0.710 ± 0.04, Meel *et al.* (2010) as 0.422 ± 0.118 in Beetal

half breed and Jamunapari goats and Bhakar (2014) as 0.50 ± 0.087 in Sirohi, respectively.

The heritability of 3 months body weight (3WT) was worked out as 0.693 ± 0.115. Heritability for weaning weight was more than birth weight indicating that population was exhibiting more genetic variability at three months of age than at birth. The selection of the sires and dams on the basis of their own body weights at 3 months of age might prove quite effective for bringing out genetic improvement. Similar result was reported by Bhakar (2014) as 0.70 ± 0.114 in Sirohi goats. Lower estimates were reported by Mehta *et al.* (1997) as 0.26 ± 0.13, Shinde *et al.* (2002) as 0.184 ± 0.034, Tomar *et al.* (2004) as 0.11 ± 0.17 and Meel *et al.* (2010) as 0.555 ± 0.136 in Sirohi goats. Comparatively higher estimate 0.78±0.03 was obtained by Akpa *et al.* (2009) in Red Sokoto goats.

The heritability of 6 months body weight (6WT) was estimated as 0.563 ± 0.105. At six months, maternal effects are reduced considerably and there is also similar plane of nutrition for all the individuals in the flock. This might have helped to reduce the environmental variability resulting in higher heritability values. Therefore, weight at six months can be considered a criterion for selecting animals. Other workers also estimated the heritability in Sirohi goats *viz.* Mehta *et al.* (1997) as 0.30 ± 0.19, Shinde *et al.* (2002) as 0.209 ± 0.068, Tomar *et al.* (2004) as 0.18 ± 0.19, Meel *et al.* (2010) as 0.686 ± 0.152 and Bhakar (2014) as 0.62 ± 0.108.

The heritability estimate of nine months body weight (9WT) was 0.560 ± 0.112. Lower values were estimated by Mehta *et al.* (1997) as 0.27 ± 0.17 and Tomar *et al.* (2000) as 0.308 ± 0.056 in Sirohi, Singh *et al.* (2009) as 0.295 ± 0.062 in Jamunapari and Yadav *et al.* (2013) as 0.204 ± 0.110 in Kutchi goats. Higher estimate was reported by Meel *et al.* (2010) as 0.726 ± 0.157 and Bhakar (2014) as 0.64 ± 0.115 in Sirohi goats.

The heritability estimate of twelve months body weight (12WT) was estimated as 0.475 ± 0.111. Other workers also estimated the heritability in Sirohi goats *viz.* Mehta *et al.* (1997) as 0.13 ± 0.16, Tomar *et al.* (2000) as 0.302±0.056, Shinde *et al.* (2002) as 0.174±0.098 and Bhakar (2014) as 0.75 ± 0.137.

4.3.2 Genetic correlations

Genetic correlations are mainly attributed to the pleiotropic effects of genes and linkage of genes governing different traits. These are helpful in predicting correlated response to selection. In case of positive correlation between traits, response to selection is more because selection for one automatically improves other depending upon the degree of correlation. Whereas, negative correlation between two desirable traits or positive correlation of desirable with undesirable trait have the same effect of impeding the progress.

Estimated genetic correlations between body weights at different ages are presented in Table 4.3 and discussed as under:

Estimates of genetic correlations between body weights at different ages ranged from 0.245 ± 0.175 between BWT and 9WT to 0.926 ± 0.038 between 6WT and 9WT.

The genetic correlations of birth weight with body weights at 3, 6, 9 and 12 months of age were estimated as 0.391 ± 0.151, 0.301 ± 0.301, 0.245 ± 0.175 and 0.449 ± 0.158, respectively. The positive and moderate correlations indicate that kids with heavier birth weight might be heavier at subsequent ages. The result was in accordance with the findings of Rai *et al.* (2004) in Marwari goats.

The genetic correlation of three months body weight with weights at 6, 9 and 12 months of age were estimated as 0.864 ± 0.052, 0.772 ± 0.085 and 0.899 ± 0.063, respectively. The positive and high correlations indicate that kids with heavier weaning weight might be heavier at subsequent ages. Selection of individuals at 3 months can be a good criterion for genetic gain in the future, if maternal effects are

taken into consideration effectively. Similar results were observed by Yadav *et al.* (2008) in Kutchi goats, Thiruvenkadan *et al.* (2009) in Tellicherry goats and Bhakar (2014) in Sirohi goats. Lower results were obtained by Singh *et al.* (2009) and Singh *et al.* (2013) in Jamunapari goats. Ekambaram *et al.* (2010) in Mahbubnagar goats estimated higher correlations than the present study.

The genetic correlation of six months body weight with weights at 9 and 12 months of age were estimated as 0.926 ± 0.038 and 0.891 ± 0.059, respectively. The result indicated that these traits were genetically related and governed by some common genes. The selection for heavier weight at 6 months should result in heavier subsequent weights. Meel *et al.* (2010) estimated similar results in Sirohi goats.

The genetic correlation of body weight at 9 months of age with that of 12 months body weight was found to be positive and high as 0.890 ± 0.053. Lower estimates were found by Rout *et al.* (2002) and Singh *et al.* (2009) in Jamunapari goats. Whereas, Thiruvenkadan *et al.* (2009), Ekambaram *et al.* (2010) and Meel *et al.* (2010) reported higher estimates than the present study in Tellicherry, Mahbubnagar and Sirohi goats, respectively. The result indicated that if animal weighed heavier at 9 months of age it would also be heavier at 12 months of age.

High genetic correlations between body weights suggest that many of the genetic factors that influence body weight at weaning to adult stage were the same. On the basis of high genetic correlation of 6WT-9WT and 6WT-12WT, it can be concluded that animals with above average 6 months body weight would tend to be above average in genetic merit for 9 and 12 months body weight. High genetic correlations between 3WT and post 3WT's are indicative of similar response to the selection, if selection is carried out at weaning age.

4.3.3 Phenotypic correlations

Phenotypic correlation is joint function of the genotype, and environment and interaction if any between the two traits. It is the association between phenotypic values of different traits measured on the same animal. The estimates of phenotypic correlations between body weights at different ages are presented in table 4.3 and are discussed as follows:

Estimates for phenotypic correlations between body weights at different ages ranged from 0.161 ± 0.028 between BWT and 9WT to 0.685 ± 0.015 for 6WT and 9WT.

The estimates phenotypic correlations of birth weight with body weight at 3, 6, 9 and 12 months of ages were estimated as 0.251 ± 0.027, 0.172 ± 0.028, 0.161 ± 0.028 and 0.181 ± 0.028, respectively. It was indicated that the phenotypic correlation of birth weight had positive but decreasing trend (except between 6 months weight and 12 months body weight) with the body weight at subsequent ages. This influence decreases in post-weaning life, as the kid is totally dependent on nutrition available through grazing land after weaning. It is the individual's genetic capacity for growth that matters after weaning. Therefore, the kid that weighed more at birth due to favorable effect of dam may not be expected to perform the same after weaning if it is genetically poor. This might be the reason of the decreasing correlation of the birth weight with body weight at higher ages. The result was in the range of the estimates of Harmiz *et al*. (2009), Meel *et al.* (2010) and Bhakar (2014).

The phenotypic correlations of 3 months body weight with weight at 6, 9 and 12 months of ages were estimated as 0.623 ± 0.018, 0.447 ± 0.023 and 0.387 ± 0.025, respectively. These estimates too showed a decreasing trend probably due to maternal influence up to weaning age. These results were similar to the findings of Tomar *et al.* (2000) in Sirohi goats and Singh *et al.* (2013) in Jamunapari goats.

The estimates phenotypic correlations of 6 months body weight with weight at 9 and 12 months of ages were observed as 0.685 ± 0.015 and 0.510 ± 0.021, respectively. The high and positive correlations at this stage indicated that a kid weighed heavier at 6 months of age, was likely to be heavier at 9 and 12 months of ages. The findings were in close agreement with the findings of Rout *et al.* (2002) in Jamunapari goats and Hermiz *et al.* (2009) in Iraqi Local goats. Higher estimates were recorded by Thiruvenkadan *et al.* (2009) in Tellicherry, Meel *et al.* (2010) in Sirohi and Singh *et al.* (2013) in Jamunapari goats.

In the field condition, the earliest age at which goats are purchased is around six months and hence weight at six months would be important criteria for evaluation of kids in field conditions.

The estimate of phenotypic correlation between body weights at 9 and 12 months of age was 0.680 ± 0.015. The findings were in close agreement with the findings of Rout *et al.* (2002) in Jamunapari and Meel *et al.* (2010) in Sirohi goats. Whereas, higher estimates were reported by Yadav *et al.* (2003, 2008) in Kutchi and Rai *et al.* (2004) in Marwari goats.

4.4 Morphometric traits at different ages:

The estimates of overall least-squares means of morphometric traits (Body height, Body length and Body girth) at birth, 3, 6, 9 and 12 months of ages are given in Table 4.7, 4.8 and 4.9.

The average body height, at birth was found to be 31.02 ± 0.35 cm, a finding in close agreement with Pathodiya *et al.* (2004). The lower estimates of 19.60 ± 0.86 cm reported by Baruna *et al.* (2002) and highest of 34.96 ± 0.11 cm reported by Joshi (1991) in Sirohi goats at birth. The estimate of average body length at birth was found to be 28.29 ± 0.39 cm. The present study was in close agreement with the report of Pathodiya *et al.* (2003) as 28.32 ± 0.02 cm in Sirohi goats. The lower estimates were reported by Singh and Sengar (1990) in

Barbari goats and Black Bengal goats, Singh and Rout (2001) in Sirohi goats, Baruna *et al.* (2002) in Beetal and Asam local goats. The highest body length of 32.81 ± 0.20 cm was reported by Pathodiya *et al.* (2002) in Sirohi goats at birth. The average body girth at birth was found to be 31.19±0.41 cm in present study, it was in close agreement with Pathodiya *et al.* (2003 & 2004) and Pathodiya (2004) in Sirohi goats, Kharkar *et al.* (2014) in Berari goats and Kumar *et al.* (1992) in Chegu goats. The lower estimates were reported by Baruna *et al.* (2002), Kumar and Singh (1983), Singh and Sengar (1990), Singh and Rout (2001) in Sirohi goats, Kumar and Singh (1983), Singh and Sengar (1990) in Black Bengal goats. The highest body girth of 35.41 ± 0.36 cm was reported by Singh and Sengar (1990) in Jamunapari goats.

The average three months body height was 51.53 ± 1.19 cm in present study. However, three months body height observed in this study was higher than the value reported by Pathodiya *et al.* (2003 and 2004) in Sirohi goats, Patro and Mishra (1987) in Ganjam goats, Kumar *et al.* (1992) in Jamunapari goats, Singh and Rout (2001) in Barbari goats and Kharkar *et al.* (2014) in Berari goats. The average three months body length was 47.90 ± 1.20 cm in present study which was in close agreement with Tomar *et al*. (2001) in Sirohi goats and Thiruvendam *et al.* (2000) in Kanni Adu goats. The lower estimates were reported by Pathodiya *et al.* (2003 and 2004) in Sirohi goats, Patro and Mishra (1987) in Ganjam goats, Kumar *et al.* (1992) in Jamunapari goats, Singh and Rout (2001) in Barbari goats and Kharkar *et al.* (2014) in Berari goats. The average three months body girth was 51.62± 1.18 cm in present study, which was lower than those reported by Joshi (1991) in Sirohi goats. The highest body height, body length and body girth of 56.20 ± 0.15 cm, 52.58 ± 0.23 cm and 52.21 ± 0.12 cm, respectively were reported by Joshi (1991) in Sirohi goats.

The average six months body height was 57.65 ± 0.95 cm, which was in close agreement with Tomar *et al.* (2001) in Sirohi goats.

However six months height observed in this study was lower than values reported by Joshi (1991) in Sirohi goats, Thiruvendam *et al.* (2000) in Kanni Adu goats and Kharkar *et al.* (2014) in Berari goats. The average six months body length was 53.96 ± 1.01 cm, which was lower than values reported by Joshi (1991) in Sirohi goats and Kumar and Singh (1983) in Jamunapari goats. The average six months body girth was 58.64 ± 1.00 cm. However, Joshi (1991), Tomar *et al.* (2001) in Sirohi goats and Kumar *et al.* (1992) in Jamunapari goats observed lower six months body girth as compared to present study.

The average nine months body height was 61.76 ± 2.24 cm. However, Pathodiya *et al.* (2003 & 2004) in Sirohi goats, Kumar *et al.* (1992) in Jamunapari goats and Singh and Rout (2000) in Barbari goats observed lower values of six months body height as compared to present study. The average nine months body length was 57.36 ± 2.16 cm, in present study similar observation was reported by Kumar *et al.* (1992) in Jamunapari goats. The average nine months body girth was 62.26± 2.35 cm in present study, which was higher than values reported by Pathodiya *et al.* (2003 & 2004) in Sirohi goats, Patro and Mishra (1987) in Ganjam goats and Singh and Rout (2000) in Barbari goats. However higher observation was reported by Thiruvendam *et al.* (2000) in Kanni Adu goats.

The average twelve months body height was 67.09 ± 0.95 cm in present study. Similar value was observed by Thiruvendam *et al.* (2000) in Kanni Adu goats. However, Pathodiya *et al.* (2003 & 2004) reported lower value of twelve months height in Sirohi goats. The average twelve months body length was 62.65 ± 098 cm in present study, which was similar with Barbari goats reported by Singh and Rout (2001). The average twelve months body girth was 67.51 ± 1.06 cm in present study, which was higher than values reported by Pathodiya *et al.* (2003 & 2004) in Sirohi goats, Patro and Mishra (1987) in Ganjam goats, Kumar *et al.* (1992) in Jamunapari goats, Singh and Rout (2001) in Barbari goats and Kharkar *et al.* (2014) in Berari goats.

4.5 Genetic and non-genetic factors affecting morphometric traits at different ages

As revealed by ANOVA given in Table 4.4, 4.5 and 4.6 various effects of genetic and non-genetic factors affecting morphometric traits at different ages were presented.

4.5.1 Effect of sire

The effect of sire was found to be highly significant (P≤ 0.01) on morphometric traits (body height, body length and body girth) at birth, 3, 6, 9 and 12 months of age. The finding was in agreement with the observations of Kumar *et al.* (1992) in Jamunapari goats and Karna *et al.* (2001) in Chegu goats.

Sire significantly affected the morphometric traits at all ages indicating existence of additive genetic variability among these traits and significant influence of sire might be attributed to relative merits of the sires used.

4.5.2 Effect of cluster

The effect of cluster was found to be highly significant (P≤ 0.01) on all morphometric traits at birth, 3, 6, 9 and 12 months of ages (Figure 6-20). Findings are in agreement with Joshi (1991) in Sirohi goats. Sharma *et al*. (2010) observed highly significant (P≤ 0.01) effect of cluster on body height and body length at birth and 3 months of age in Sirohi goats, body girth at 3 months of age. However, Rao and Patro (2002) observed significant effect on body length and body girth at birth and Kharkar *et al.* (2014) observed significant effect on body length at birth.

4.5.3 Effect of year of birth

The effect of year of birth was found to be highly significant (P≤ 0.01) on all morphometric traits at birth, 3, 6, 9 and 12 months of ages (Figure 6-20). Present findings are similar with Tomar *et al.* (2001) except at birth in body height in Sirohi goats, Sharma *et al*. (2010) observed highly significant (P≤ 0.01) effect of cluster on all three morphometric traits at birth and 3 months of age in Sirohi goats. Khan and Sahni (1983) at 3 months of body height and body length, Kumar *et al.* (1992) observed significant effect of year of birth on body length at 3 months, body height at birth, 3 and 6 months of ages, body girth at birth, 3, 6, and 9 months of ages in Jamunapari goats and Karna *et al.* (2001) at birth on all three morphometric traits in Chegu goats.

Higher values of all three morphometric traits were observed at birth in initial two years (2007-2008 and 2008-2009) then it remain almost constant. A body height was decline upto second year and then again remains constant. A body girth was continuously decline at 6 and 9 months of age. Highest body length was observed in first year of birth (2007-2008), whereas body height and body girth in last year of birth (2012-2013). This might be due to the differences in climate, nutrition and management.

4.5.4 Effect of season of birth

Influence of season of birth was highly significant (P≤ 0.01) on body height at 3 and 12 months of ages, significant at birth and 9 months of ages and non-significant at 6 months of age (Figure 6, 7, 9 and 10). Highly significant (P≤ 0.01) effect was observed on body girth at birth, 3 and 12 months of ages (Figure 16, 17 and 20), also on body length at birth and 3 months of ages (Figure 11-12). Similar results were also observed by Joshi (1991) and Pathodiya *et al.* (2004) in Sirohi goats. However Sharma *et al.* (2010) reported significant (P≤ 0.05) effect of season of birth on body height and body length at birth, highly significant (P≤ 0.01) effect on all three morphometric traits at 3

months of age. Karna *et al.* (2001) reported significant effect at birth on body length in Chegu goats, Kharkar *et al.* (2014) at 3 months on body length, 3 and 12 months body height and at birth and 12 months body girth on Berari goats.

Summer born kids at birth have higher body height, body length and body girth compared with rainy season and winter season. Kids attended maximum body height and body girth which born in rainy season.

4.5.5 Effect of sex of kid

Sex of kids had highly significant effect (P≤ 0.01) on all three morphometric traits at birth, 3, 6, 9 and 12 months of ages (Figure 6-20). However, the male kids were larger to females one with regards to their body height, body length and body girth at all the ages. These results are in agreement with the findings of Joshi (1991), Tomar *et al.* (2001), Pathodiya *et al.* (2004) in Sirohi goats and Sharma *et al.* (2010) reported highly significant (P≤ 0.01) effect of sex of kid on body length and body girth at birth. Kumar *et al.* (1992) in Jamunapari goats except at 3 months body length and body height. However, non-significant effect of sex of kids on body height, body length and body girth on all ages was observed by Rao and Patro (2002) in Ganjam goats and Kharkar *et al.* (2014) in Berari goats.

4.5.6 Effect of type of birth

The type of birth had highly significant effect (P≤ 0.01) on all three morphometric traits at birth, 3, 6, 9 and 12 months of ages (Figure 6-20). These findings were supported by Joshi (1991) at birth on body length, at birth and 6 months on body height and at birth, 3 and 6 months body girth and Tomar *et al.* (2001) at birth, 3 and 6 months of age on all three morphometric traits in Sirohi goats and Khan and Sahni (1992) in Jamunapari goats. Sharma *et al.* (2010) reported highly significant effect (P≤ 0.01) of type of birth on all three

morphometric traits at birth, significant effect (P≤ 0.05) on body height at 3 months of age. However, non-significant effect of type of birth on body height, body length and body girth on all ages was observed by Kharkar *et al.* (2014) in Berari goats.

Single born kids were larger in body height, body length and body girth than those born as multiple at all the ages. This might be due to availability of more nutrients to the single born kid than those born in multiple births during pre and post natal life.

4.5.7 Effect of parity

The parity of dam had highly significant effect (P≤ 0.01) on body height and body girth at birth and at other ages non-significant effect of parity was observed (Figure 6 and 16). Body length had non-significant effect of parity on all ages in the present study. Similar effect of dam's parity on morphometric traits at all ages was reported by Nahardeka (2000) in Assam local goats. However, Pathodiya *et al.* (2004) reported significant effect of parity of dam on all morphometric traits at birth in Sirohi goats.

4.5.8 Effect of dam's weight at kidding

The regression of dam's weight at kidding had highly significant (P≤ 0.01) effect at birth and 12 months of ages, significant (P≤ 0.05) effect on 3, and 6 months of ages on body height, highly significant (P≤ 0.01) effect at birth and 12 months of ages, significant (P≤ 0.05) effect on 6 months of age on body length and body girth at birth, 3 and 12 months of ages. However, Kumar et al. (1992) reported non-significant effect of dam's weight at kidding on all morphometric traits at 6, 9 and 12 months of ages in Jamunapari goats and Sharma *et al.* (2010) also reported non-significant effect on all morphometric traits at birth and 3 months of age.

Table 4.4 Least squares analysis of variance for various factors affecting body height in Sirohi goats

SOURCE OF VARIATION	BBH		3 BH		6 BH		9 BH		12 BH	
	D.F	M.S.	D.F	M.S.	D.F	M.S.	D.F	M.S.	D.F	M.S.
Sire	58	40.35**	54	215.02**	52	102.09**	49	156.38**	48	110.44**
Cluster	4	465.77**	4	1640.5**	4	837.65**	4	815.24**	4	1103.91**
Season	2	8.51*	2	95.40**	2	1.74	2	32.83*	2	57.60*
Year	5	67.46 **	5	217.27**	5	405.21**	5	358.91**	5	118.26**
Parity	4	8.98**	4	6.74	4	11.54	4	9.95	4	10.02
Type of birth	1	3080.7**	1	2436.5**	1	1658.2**	1	542.17**	1	325.87**
Sex	1	511.76**	1	2731.0**	1	1568.4**	1	1250.85**	1	821.12**
Reg. on DWK	1	47.97**	1	44.06*	1	35.76*	1	9.82	1	78.02*
Error	3474	2.485893	3000	9.430961	2123	8.729738	1574	10.887407	1079	10.375240

Note : BBH= Body height at birth, 3 BH= 3 months body height, 6 BH= 6 months body height,
9 BH= 9 months body height, 12 BH= 12 months body height.
D.F. =Degree of freedom, M.S. = Mean squares, Reg. on DWK = Regression on weight of dam at kidding
** = Highly significant (P≤0.01), *= Significant (P≤0.05)

Table 4.5 Least squares analysis of variance for various factors affecting body length in Sirohi goats

SOURCE OF VARIATION	BBL		3 BL		6 BL		9 BL		12 BL	
	D.F	M.S.	D.F	M.S.	D.F	M.S.	D.F	M.S.	D.F	M.S.
Sire	58	50.19**	54	220.58**	52	114.18**	49	145.49**	48	117.28**
Cluster	4	114.52**	4	592.45**	4	848.89**	4	724.86**	4	888.00**
Season	2	26.52**	2	74.40**	2	12.09	2	20.63	2	8.38
Year	5	70.84**	5	369.68**	5	463.52**	5	598.12**	5	291.34**
Parity	4	3.88	4	7.78	4	11.85	4	7.58	4	7.92
Type of birth	1	2995.5**	1	1919.8**	1	1820.2**	1	562.77**	1	235.92**
Sex	1	367.02**	1	1978.3**	1	1196.9**	1	1349.62**	1	912.60**
Reg. on DWK	1	49.52**	1	6.70	1	49.47*	1	18.22	1	73.75**
Error	3474	2.800140	3000	10.366704	2123	8.928406	1574	11.510327	1079	10.329582

Note : BBL= Body length at birth, 3 BL= 3 months body length, 6 BL= 6 months body length,
9 BL= 9 months body length, 12 BL= 12 months body length.
D.F. =Degree of freedom, M.S. = Mean squares, Reg. on DWK = Regression on weight of dam at kidding
** = Highly significant (P≤0.01), *= Significant (P≤0.05)

Table 4.6 Least squares analysis of variance for various factors affecting body girth in Sirohi goats

SOURCE OF VARIATION	BBG		3 BG		6 BG		9 BG		12 BG	
	D.F	M.S.	D.F	M.S.	D.F	M.S.	D.F	M.S.	D.F.	M.S.
Sire	58	55.00**	54	211.87**	52	111.65**	49	170.95**	48	136.28**
Cluster	4	198.39**	4	844.65**	4	467.16**	4	535.21**	4	699.20**
Season	2	23.01**	2	107.03**	2	5.38	2	22.40	2	58.87**
Year	5	100.06**	5	249.75**	5	364.96**	5	362.81**	5	118.78**
Parity	4	9.14**	4	12.45	4	11.50	4	12.44	4	2.91
Type of birth	1	2980.6**	1	2585.7**	1	1594.2**	1	440.27**	1	421.34**
Sex	1	529.72**	1	2557.7**	1	1599.4**	1	1239.92**	1	825.01**
Reg. on DWK	1	16.42*	1	47.10*	1	8.51	1	0.33	1	74.51**
Error	3474	2.613754	3000	9.538991	2123	10.281957	1574	10.863995	1079	10.660491

Note : BBG=Body girth at birth, 3 BG= 3 months body girth, 6 BG= 6 months body girth,
9 BG= 9 months body girth, 12 BG= 12 months body girth.
D.F. =Degree of freedom, M.S. = Mean squares, Reg. on DWK = Regression on weight of dam at kidding
** = Highly significant (P≤0.01), *= Significant (P≤0.05)

Table No. 4.7. Least-squares means and S.E. for body height (cm) of Sirohi goat at different ages

Traits / Factors	At birth	3 month	6 month	9 month	12 month
Overall mean (μ)	31.02 ± 0.35 (3551)	51.53 ± 1.19 (3073)	57.65 ± 0.95 (2194)	61.76 ± 2.24 (1642)	67.09 ± 0.95 (1144)
Sire	**	**	**	**	**
Cluster	**	**	**	**	**
Vallabhnagar	29.16 ± 0.38^{a} (278)	50.54 ± 1.23^{b} (214)	55.52 ± 1.04^{b} (123)	59.10 ± 2.30^{a} (59)	59.54 ± 1.65^{a} (36)
Railmagra	31.03 ± 0.38^{b} (650)	47.35 ± 1.22^{a} (593)	57.44 ± 1.01^{c} (504)	60.71 ± 2.27^{b} (396)	65.82 ± 1.10^{c} (229)
Devgarh	31.70 ± 0.38^{c} (1584)	52.63 ± 1.22^{cb} (1439)	57.42 ± 1.65^{c} (1184)	61.62 ± 2.27^{c} (943)	64.76 ± 1.12^{b} (715)
Nathdwara	29.38 ± 0.61^{a} (37)	51.31 ± 1.71^{b} (15)	53.42 ± 1.65^{a} (12)	56.75 ± 3.07^{a} (3)	-----
Bhadsoda	33.85 ± 0.38^{d} (1002)	55.81 ± 1.22^{d} (812)	64.47 ± 1.03^{d} (371)	70.63 ± 2.28^{d} (241)	78.24 ± 1.17^{d} (164)
Season	*	**	NS	*	**
Rainy	30.95 ± 0.35^{a} (1303)	51.18 ± 1.19^{a} (1171)	57.64 ± 0.96 (795)	61.96 ± 2.25^{b} (507)	67.61 ± 0.96^{b} (377)
Winter	30.96 ± 0.35^{a} (1723)	51.78 ± 1.19^{b} (1443)	57.59 ± 0.96 (1021)	61.96 ± 2.25^{b} (829)	66.99 ± 0.95^{a} (589)
Summer	31.16 ± 0.36^{b} (525)	51.63 ± 1.19^{b} (459)	57.71 ± 0.97 (378)	61.36 ± 2.27^{a} (306)	66.66 ± 0.98^{a} (178)
Year of birth	**	**	**	**	**
2007-08	32.16 ± 0.38^{d} (491)	53.21 ± 1.22^{d} (453)	59.40 ± 1.00^{f} (404)	63.92 ± 2.27^{d} (350)	66.28 ± 1.03^{a} (310)
2008-09	31.53 ± 0.37^{c} (586)	50.98 ± 1.22^{b} (530)	56.17 ± 1.00^{a} (412)	61.36 ± 2.27^{b} (316)	65.74 ± 1.03^{a} (209)
2009-10	30.38 ± 0.36^{a} (624)	50.54 ± 1.20^{a} (525)	56.42 ± 0.97^{a} (394)	59.82 ± 2.25^{a} (320)	66.44 ±0.99^{ba} (186)
2010-2011	30.38 ± 0.36^{a} (531)	51.25 ± 1.20^{b} (467)	57.24 ± 0.98^{c} (376)	61.24 ± 2.26^{b} (308)	67.68 ± 1.02^{c} (218)
2011-2012	30.91 ± 0.36^{b} (668)	51.91 ± 1.20^{c} (570)	58.90 ± 0.98^{e} (406)	62.86 ± 2.26^{c} (301)	69.31 ± 1.02^{d} (221)
2012-2013	30.79 ± 0.36^{b} (651)	51.29 ± 1.21^{b} (528)	57.74 ± 1.00^{d} (202)	61.37 ± 2.32^{b} (47)	-----
Parity	**	NS	NS	NS	NS
1st	30.97 ± 0.36^{a} (278)	51.43 ± 1.20 (664)	57.74 ± 0.97 (507)	61.88 ± 2.25 (393)	67.41 ± 0.98 (276)
2nd	31.06±0.35^{ba} (650)	51.44 ± 1.19 (589)	57.82 ± 0.96 (455)	61.84 ± 2.25 (348)	67.18 ± 0.97 (243)
3rd	30.89 ± 0.36^{a} (1584)	51.46 ± 1.19 (553)	57.51 ± 0.96 (411)	61.55 ± 2.25 (303)	67.25 ± 0.97 (220)
4th	30.99 ± 0.36^{a} (37)	51.74 ± 1.19 (461)	57.76 ± 0.97 (317)	61.99 ± 2.25 (218)	66.77 ± 0.98 (152)
≥ 5th	31.20 ± 0.35^{ba} (1002)	51.58 ± 1.19 (806)	57.40 ± 0.96 (504)	61.55 ± 2.25 (380)	66.84 ± 0.97 (253)

Type of birth	**	**	**	**	**
Single	32.12 ± 0.35[b] (2080)	52.58 ± 1.19[b] (1842)	58.70 ± 0.96[b] (1386)	62.46 ± 2.24[b] (1049)	67.74 ± 0.95[b] (752)
Multiple	29.93 ± 0.35[a] (1471)	50.48 ± 1.19[a] (1231)	56.60 ± 0.96[a] (808)	61.06 ± 2.25[a] (593)	66.44 ± 0.96[a] (392)
Sex	**	**	**	**	**
Male	31.41 ± 0.35[b] (1768)	52.49 ± 1.19[b] (1536)	58.51 ± 0.96[b] (1023)	62.68 ± 2.24[b] (679)	68.04 ± 0.96[b] (372)
Female	30.64 ± 0.35[a] (1783)	50.57 ± 1.19[a] (1537)	56.78 ± 0.96[a] (1171)	60.84 ± 2.24[a] (963)	66.14 ±0.95[a] (772)
Regression on weight of dam at kidding	**	*	*	NS	**
Regression coefficient (b) (kg/kg)	0.066±0.015	0.068± 0.031	0.076±0.037	0.046±0.048	0.157±0.057

NOTE: No. of observations are given in parentheses. Estimates with different superscripts differ significantly. ** = Highly significant (P≤0.01), * = Significant (P≤0.05), NS = Non-significant

Table No. 4.8. Least-squares means and S.E. for body length (cm) of Sirohi goat at different ages

Traits / Factors	At birth	3 month	6 month	9 month	12 month
Overall mean (μ)	28.29 ± 0.39 (3551)	47.90 ± 1.20 (3073)	53.96 ± 1.01 (2194)	57.36 ± 2.16 (1642)	62.65 ± 098 (1144)
Sire	**	**	**	**	**
Cluster	**	**	**	**	**
Vallabhnagar	27.16 ± 0.42^{a} (278)	48.79 ± 1.25^{b} (214)	54.01 ± 1.09^{b} (123)	56.85 ± 2.22^{b} (59)	56.55 ± 1.67^{a} (36)
Railmagra	28.65 ± 0.42^{b} (650)	45.63 ± 1.24^{a} (593)	55.48 ± 1.08^{c} (504)	59.28 ± 2.18^{c} (396)	63.90 ± 1.13^{c} (229)
Devgarh	29.71 ± 0.42^{d} (1584)	45.48 ± 1.24^{a} (1439)	50.09 ± 1.07^{a} (1184)	54.53 ± 2.19^{a} (943)	58.07 ± 1.14^{b} (715)
Nathdwara	27.00 ± 0.66^{a} (37)	49.78 ± 1.76^{bc} (15)	51.71 ± 1.70^{a} (12)	51.36 ± 3.05^{a} (3)	-----
Bhadsoda	28.93 ± 0.42^{c} (1002)	49.80 ± 1.24^{c} (812)	58.51 ± 1.09^{d} (371)	64.77 ± 2.20^{d} (241)	72.07 ± 1.19^{d} (164)
Season	**	**	NS	NS	NS
Rainy	28.21 ± 0.39^{a} (1303)	47.57 ± 1.20^{a} (1171)	53.98 ± 1.01 (795)	57.60 ± 2.16 (507)	62.74 ± 0.99 (377)
Winter	28.13 ± 0.39^{a} (1723)	48.06 ± 1.20^{b} (1443)	54.12 ± 1.02 (1021)	57.21 ± 2.16 (829)	62.47 ± 0.98 (589)
Summer	28.53 ± 0.40^{b} (525)	48.06 ± 1.21^{b} (459)	53.78 ±1.02 (378)	57.27 ± 2.16 (306)	62.74 ± 1.01 (178)
Year of birth	**	**	**	**	**
2007-08	29.62 ± 0.42^{e} (491)	49.96 ± 1.24^{d} (453)	55.68 ± 1.06^{e} (404)	60.84 ± 2.19^{d} (350)	64.47 ± 1.06^{e} (310)
2008-09	28.98 ± 0.41^{d} (586)	48.08 ± 1.23^{c} (530)	52.82 ± 1.05^{b} (412)	56.65 ± 2.19^{b} (316)	60.90 ± 1.06^{a} (209)
2009-10	27.80 ± 0.40^{b} (624)	46.00 ± 1.21^{a} (525)	52.13 ± 1.03^{a} (394)	55.25 ± 2.17^{a} (320)	61.65 ± 1.02^{b} (186)
2010-2011	27.42 ± 0.40^{a} (531)	47.63 ± 1.22^{b} (467)	53.62 ± 1.04^{c} (376)	56.50 ± 2.17^{b} (308)	62.43 ± 1.05^{c} (218)
2011-2012	27.82 ± 0.40^{b} (668)	48.13 ± 1.22^{c} (570)	55.31 ± 1.03^{e} (406)	58.20 ± 2.17^{c} (301)	63.78 ± 1.05^{d} (221)
2012-2013	28.09 ± 0.41^{c} (651)	47.58 ± 1.22^{b} (528)	54.21 ± 1.05^{d} (202)	56.72 ± 2.24^{b} (47)	-----
Parity	NS	NS	NS	NS	NS
1st	28.22 ± 0.40 (278)	47.75 ± 1.21 (664)	54.14 ± 1.03 (507)	57.60 ± 2.17 (393)	62.61 ± 1.01 (276)
2nd	28.36 ± 0.40 (650)	47.81 ± 1.21 (589)	54.17 ± 1.02 (455)	57.47 ± 2.16 (348)	62.90 ± 1.00 (243)
3rd	28.19 ± 0.40 (1584)	47.90 ± 1.21 (553)	53.79 ±1.02 (411)	57.26 ± 2.16 (303)	62.79 ± 1.00 (220)
4th	28.32 ± 0.40 (37)	48.12 ± 1.21 (461)	53.96 ± 1.02 (317)	57.36 ± 2.17 (218)	62.54 ± 1.01 (152)
≥ 5th	28.37 ± 0.40 (1002)	47.91 ± 1.21 (806)	53.75 ± 1.02 (504)	57.11 ± 2.16 (380)	62.40 ± 1.00 (253)

Type of birth	**	**	**	**	**
Single	29.37 ± 0.39[b] (2080)	48.83 ± 1.20[b] (1842)	55.06 ± 1.01[b] (1386)	58.07 ± 2.16[b] (1049)	63.20 ± 0.98[b] (752)
Multiple	27.21 ± 0.39[a] (1471)	46.96 ± 1.20[a] (1231)	52.86 ± 1.02[a] (808)	56.65 ± 2.16[a] (593)	62.09 ± 0.99[a] (392)
Sex	**	**	**	**	**
Male	28.62 ± 0.39[b] (1768)	48.71 ±1.20[b] (1536)	54.72 ± 1.01[b] (1023)	58.32 ± 2.16[b] (679)	63.65 ± 0.99[b] (372)
Female	27.96 ± 0.39[a] (1783)	47.08 ± 1.20[a] (1537)	53.20 ± 1.01[a] (1171)	56.40 ± 2.16[a] (963)	61.65 ± 0.98[a] (772)
Regression on weight of dam at kidding	**	NS	*	NS	**
Regression coefficient (b) (kg/kg)	0.067 ±0 .016	0 .027 ±0.033	0 .089 ±0.038	0 .062 ±0.050	0 .152 ±0.057

NOTE: No. of observations are given in parentheses. Estimates with different superscripts differ significantly. ** = Highly significant (P≤0.01), * = Significant (P≤0.05), NS = Non-significant

Table No. 4.9. Least-squares means and S.E. for body girth (cm) of Sirohi goat at different ages

Traits / Factors	At birth	3 month	6 month	9 month	12 month
Overall mean (μ)	31.19±0.41 (3551)	51.62± 1.18 (3073)	58.64± 1.00 (2194)	62.26± 2.35 (1642)	67.51± 1.06 (1144)
Sire	**	**	**	**	**
Cluster	**	**	**	**	**
Vallabhnagar	29.69± 0.44^{b} (278)	51.20± 1.22^{b} (214)	56.08± 1.09^{a} (123)	59.90± 2.40^{a} (59)	59.66± 1.73^{a} (36)
Railmagra	32.25± 0.44^{d} (650)	48.82± 1.21^{a} (593)	59.18± 1.07^{c} (504)	62.45± 2.37^{c} (396)	68.36± 1.20^{c} (229)
Devgarh	32.02± 0.44^{c} (1584)	52.90± 1.21^{c} (1439)	57.72± 1.06^{b} (1184)	61.84± 2.37^{b} (943)	65.24± 1.22^{b} (715)
Nathdwara	29.03± 0.66^{a} (37)	50.34± 1.70^{ab} (15)	56.81±1.77^{ab} (12)	57.43± 3.15^{a} (3)	-----
Bhadsoda	32.98± 0.43^{e} (1002)	54.84± 1.21^{d} (812)	63.43± 1.08^{d} (371)	69.71± 2.38^{d} (241)	76.77± 1.26^{d} (164)
Season	**	**	NS	NS	**
Rainy	31.20± 0.41^{b} (1303)	51.24± 1.18^{a} (1171)	58.54± 1.00 (795)	62.33± 2.35 (507)	67.93± 1.07^{b} (377)
Winter	31.02± 0.41^{a} (1723)	51.85± 1.18^{b} (1443)	58.63± 1.00 (1021)	62.50± 2.35 (829)	67.13± 1.06^{a} (589)
Summer	31.36± 0.42^{b} (525)	51.77± 1.19^{b} (459)	58.76± 1.01 (378)	61.96± 2.35 (306)	67.46± 1.08^{a} (178)
Year of birth	**	**	**	**	**
2007-08	32.82± 0.43^{d} (491)	53.85± 1.21^{d} (453)	60.62± 1.05^{e} (404)	65.01± 2.37^{d} (350)	67.34± 1.14^{b} (310)
2008-09	31.95± 0.43^{c} (586)	51.31± 1.21^{b} (525)	57.80± 1.05^{a} (412)	62.58± 2.37^{c} (316)	66.02± 1.13^{a} (209)
2009-10	30.37± 0.42^{a} (624)	50.60± 1.19^{a} (530)	57.37± 1.01^{a} (394)	60.24± 2.36^{a} (320)	66.90± 1.10^{b} (186)
2010-2011	30.79± 0.42^{b} (531)	51.19± 1.19^{b} (467)	57.85±1.02^{ba} (376)	61.33± 2.36^{b} (308)	67.89±1.12^{cb} (218)
2011-2012	30.72± 0.42^{b} (668)	51.67± 1.19^{c} (570)	59.68± 1.02^{d} (406)	62.92± 2.36^{c} (301)	69.40±1.13^{d} (221)
2012-2013	30.50± 0.42^{a} (651)	51.09± 1.20^{b} (528)	58.55± 1.04^{c} (202)	61.51± 2.42^{b} (47)	-----
Parity	**	NS	NS	NS	NS
1st	31.06± 0.42^{a} (278)	51.47± 1.19 (664)	58.63± 1.01 (507)	62.17± 2.36 (393)	67.69± 1.09 (276)
2nd	31.22± 0.42^{a} (650)	51.44± 1.18 (589)	58.73± 1.01 (455)	62.31± 2.35 (348)	67.64± 1.08 (243)
3rd	31.11± 0.42^{a} (1584)	51.58± 1.18 (553)	58.57± 1.01 (411)	62.09± 2.35 (303)	67.48± 1.08 (220)
4th	31.19± 0.42^{a} (37)	51.84± 1.19 (461)	58.88± 1.01 (317)	62.65± 2.36 (218)	67.32± 1.09 (152)
≥ 5th	31.38±0.41^{ba} (1002)	51.76± 1.18 (806)	58.41± 1.01 (504)	62.11± 2.35 (380)	67.40± 1.08 (253)

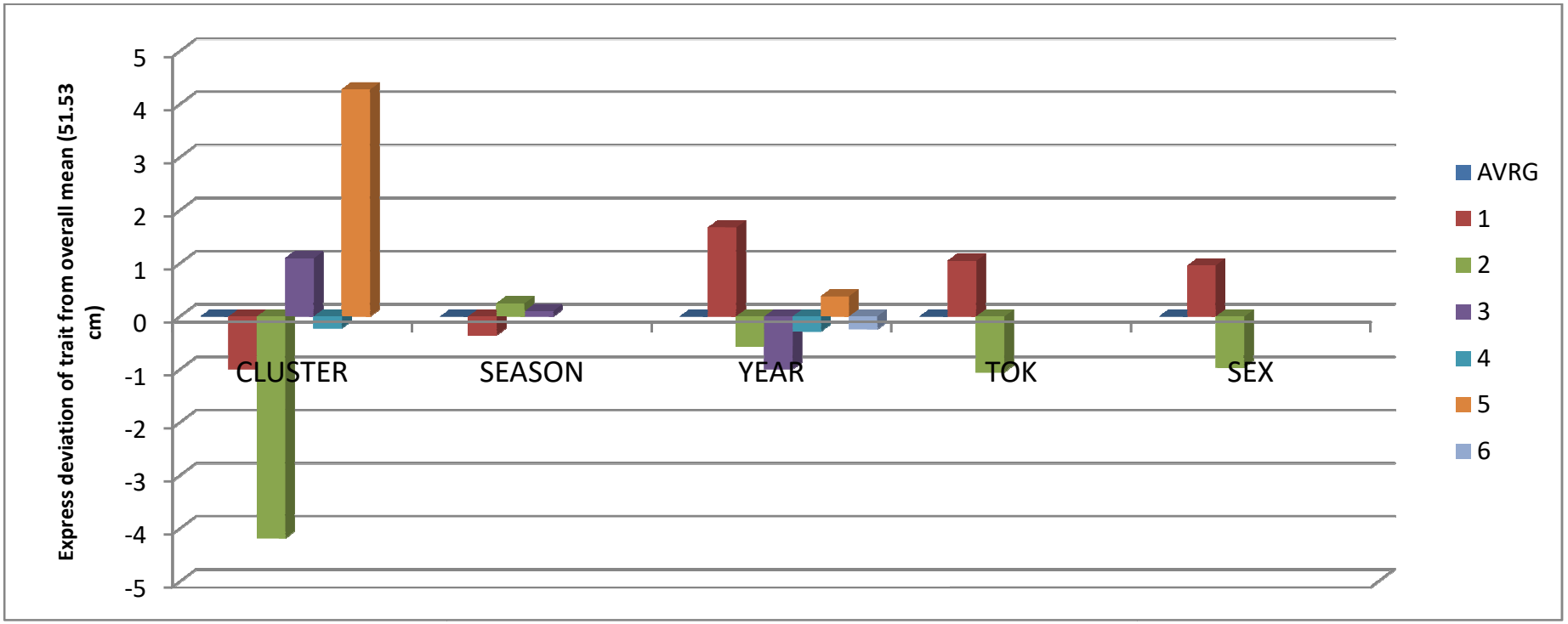
Type of birth	**	**	**	**	**
Single	32.27± 0.41[b] (2080)	52.70± 1.18[b] (1842)	59.67± 1.00[b] (1386)	62.89± 2.35[b] (1049)	68.25± 1.06[b] (752)
Multiple	30.11± 0.41[a] (1471)	50.53± 1.18[a] (1231)	57.61± 1.00[a] (808)	61.64± 2.35[a] (593)	66.77± 1.07[a] (392)
Sex	**	**	**	**	**
Male	31.58± 0.41[b] (1768)	52.55±1.18[b] (1536)	59.52± 1.00[b] (1023)	63.18±2.35[b] (679)	68.46± 1.07[b] (372)
Female	30.80± 0.41[a] (1783)	50.69±1.18[a] (1537)	57.77± 1.00[a] (1171)	61.35±2.35[a] (963)	66.56±1.06[a] (772)
Regression on weight of dam at kidding	*	*	NS	NS	**
Regression coefficient (b) (kg/kg)	0.039 ±0.015	0.071 ±0.031	0.037 ±0.041	0.008 ±0.048	0.153 ±0.058

NOTE: No. of observations are given in parentheses. Estimates with different superscripts differ significantly. ** = Highly significant (P≤0.01), * = Significant (P≤0.05), NS = Non-significant

Figure 6. Factors affecting body height at birth of Sirohi goats

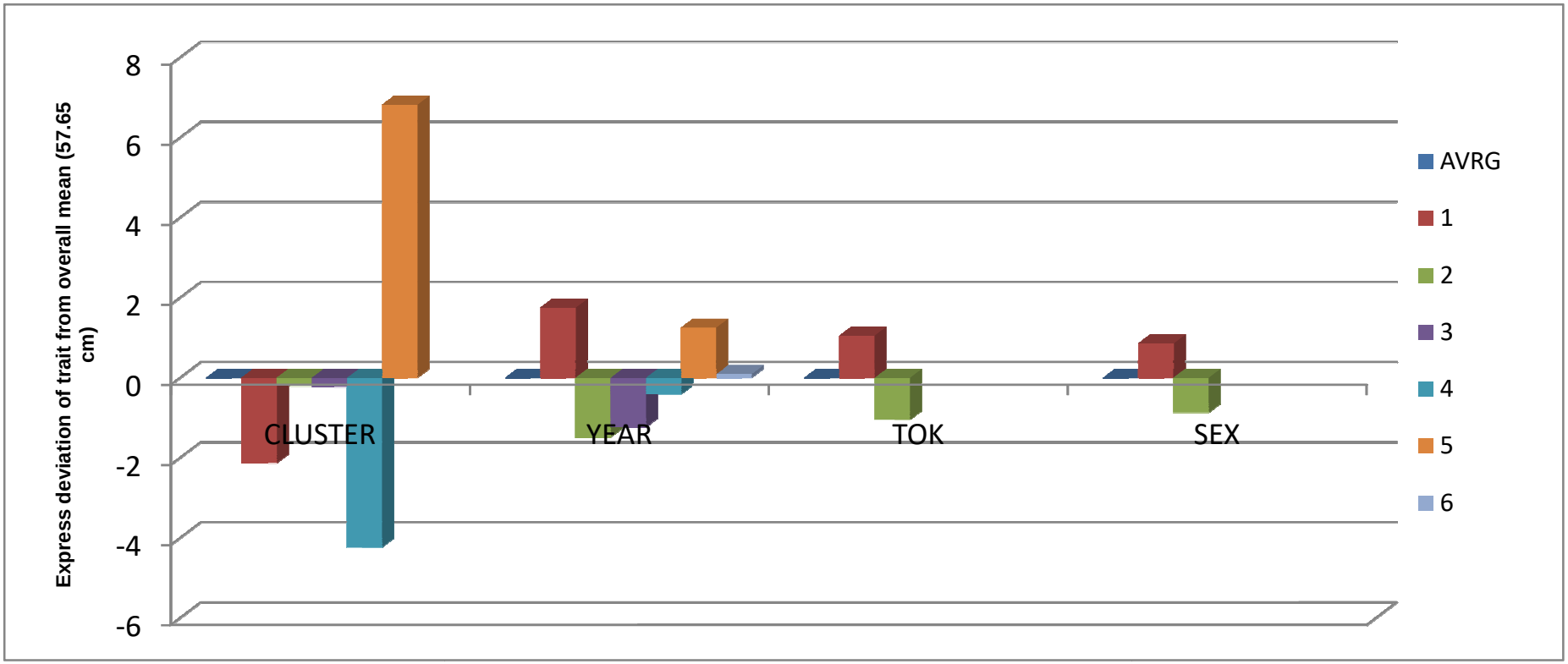
Cluster- 1 to 5 (Vallabhnagar, Railmagra, Devgarh, Nathdwara and Bhadsoda); **Season-** 1 to 3 (Rainy, Winter and Summer); **Year-** 1 to 6 (2007-08, 2008-09, 2009-10, 2010-11, 2011-12 and 2012-13); **Parity-** 1 to 5; **Type of kidding-** 1 and 2 (Single and Multiple); **Sex-** 1 and 2 (Male and Female).

Figure 7. Factors affecting 3 months body height of Sirohi goats



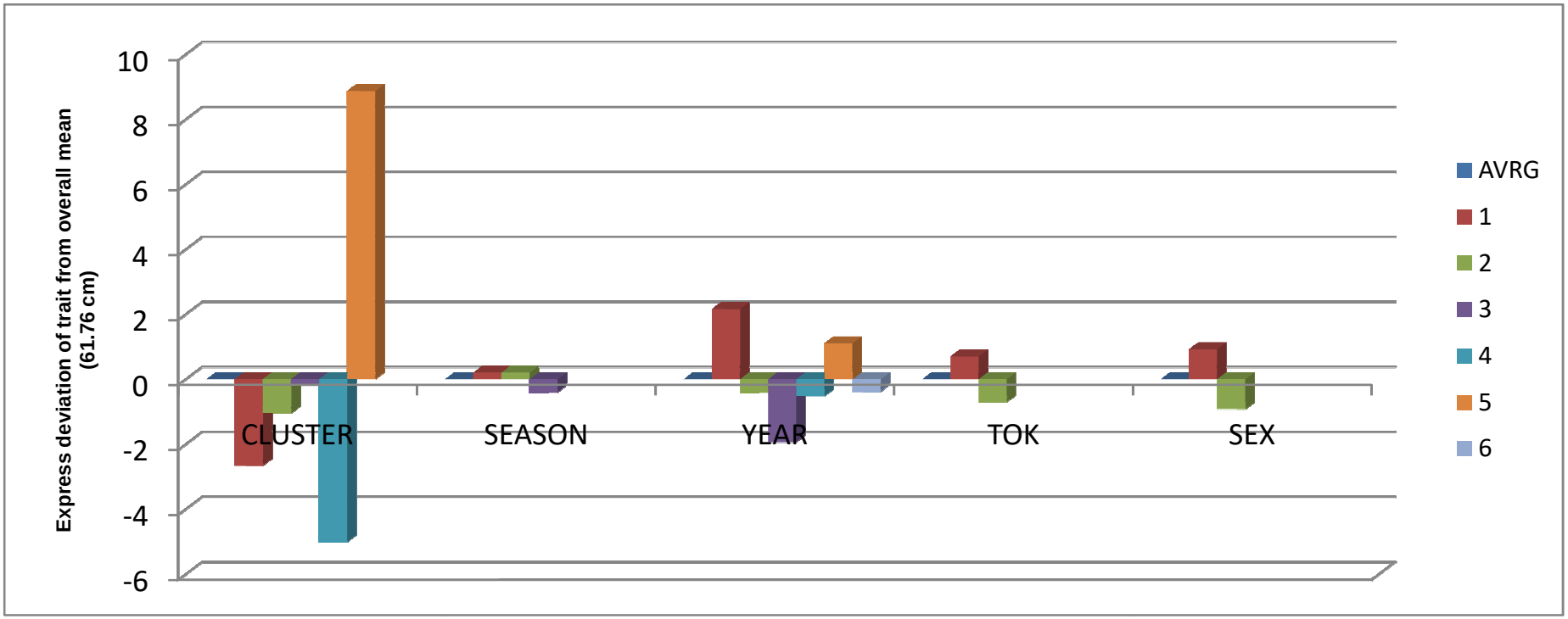
Cluster- 1 to 5 (Vallabhnagar, Railmagra, Devgarh, Nathdwara and Bhadsoda); **Season-** 1 to 3 (Rainy, Winter and Summer); **Year-** 1 to 6 (2007-08, 2008-09, 2009-10, 2010-11, 2011-12 and 2012-13); **Type of kidding-** 1 and 2 (Single and Multiple); **Sex-** 1 and 2 (Male and Female).

Figure 8. Factors affecting 6 months body height of Sirohi goats



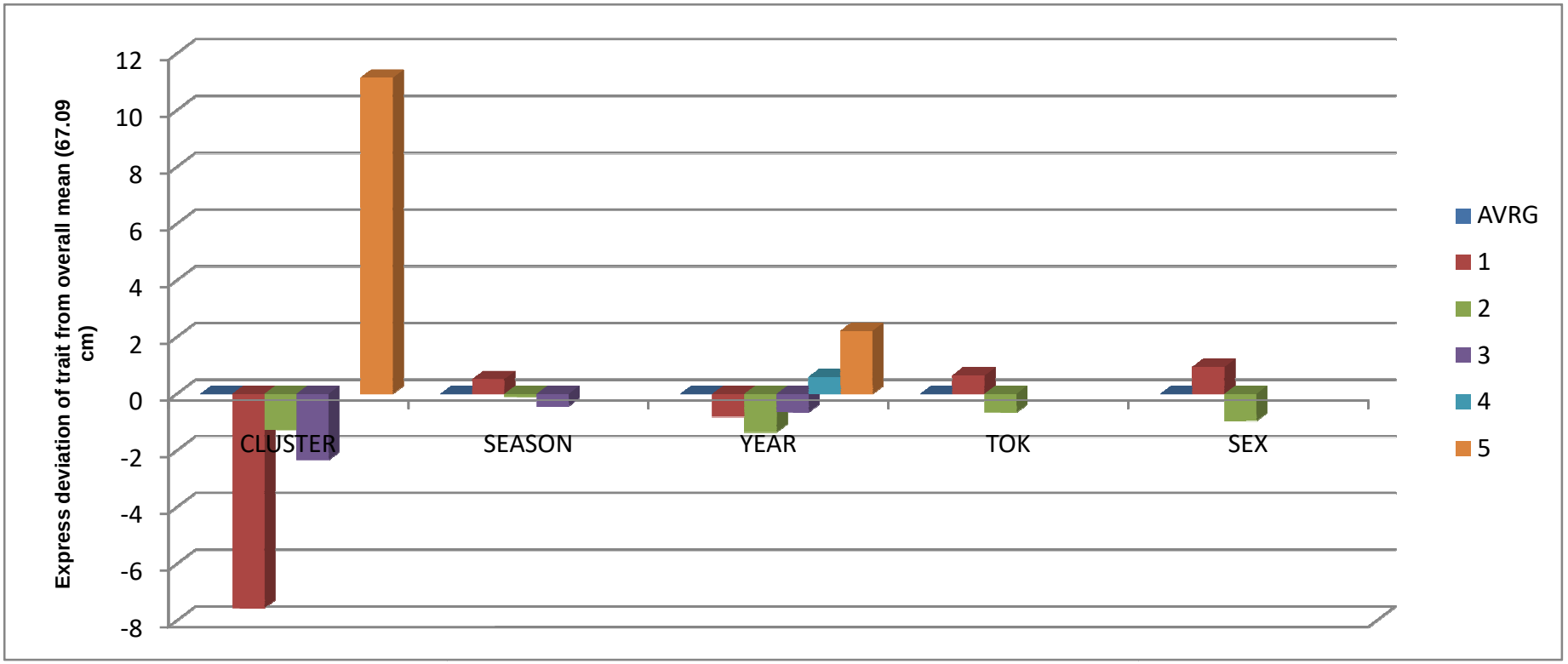
Cluster- 1 to 5 (Vallabhnagar, Railmagra, Devgarh, Nathdwara and Bhadsoda); **Year-** 1 to 6 (2007-08, 2008-09, 2009-10, 2010-11, 2011-12 and 2012-13); **Type of kidding-** 1 and 2 (Single and Multiple); **Sex-** 1 and 2 (Male and Female).

Figure 9. Factors affecting 9 months body height of Sirohi goats



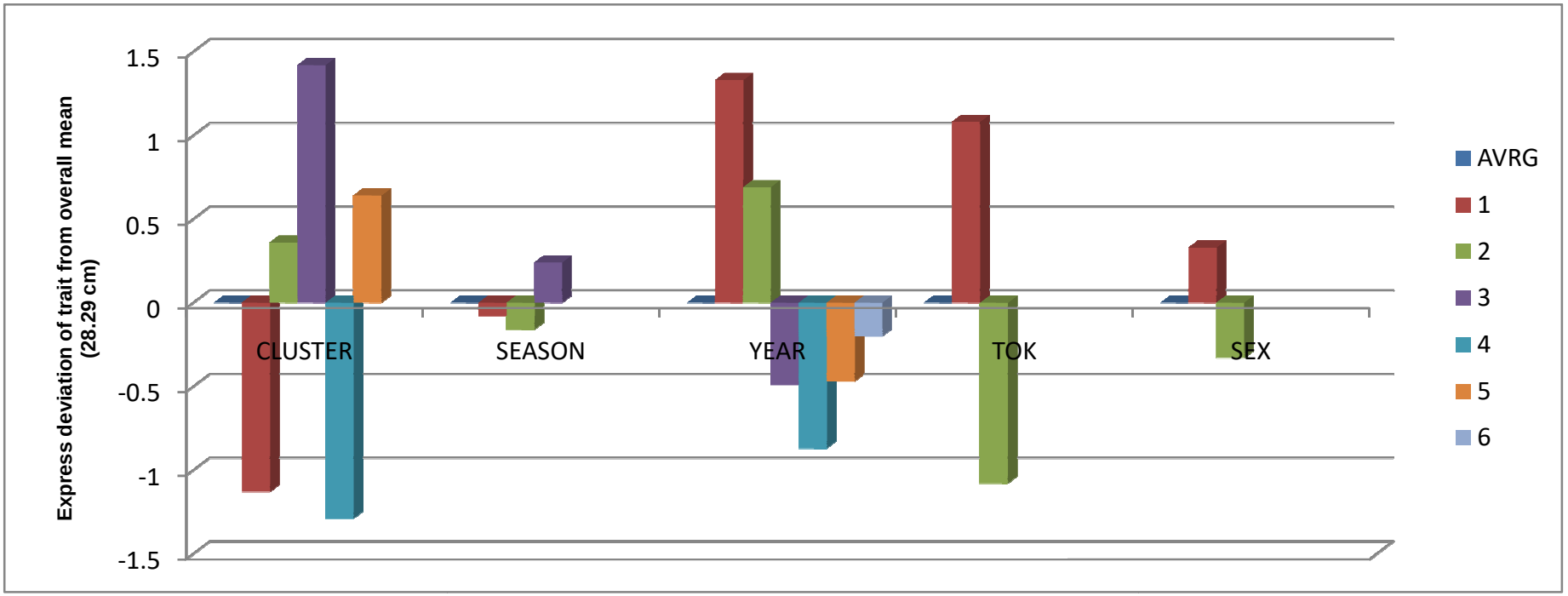
Cluster- 1 to 5 (Vallabhnagar, Railmagra, Devgarh, Nathdwara and Bhadsoda); **Season-** 1 to 3 (Rainy, Winter and Summer); **Year-** 1 to 6 (2007-08, 2008-09, 2009-10, 2010-11, 2011-12 and 2012-13); **Type of kidding-** 1 and 2 (Single and Multiple); **Sex-** 1 and 2 (Male and Female).

Figure 10. Factors affecting 12 months body height of Sirohi goats



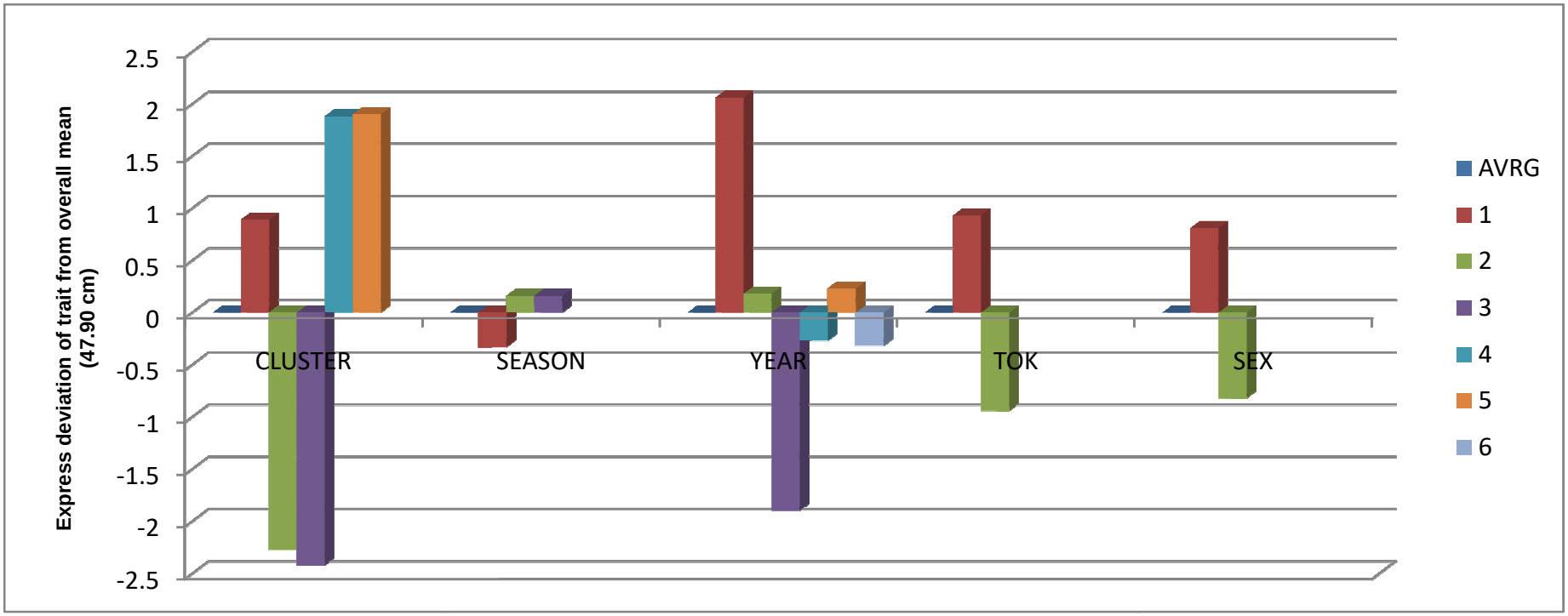
Cluster- 1 to 5 (Vallabhnagar, Railmagra, Devgarh, Nathdwara and Bhadsoda); **Season-** 1 to 3 (Rainy, Winter and Summer); **Year-** 1 to 6 (2007-08, 2008-09, 2009-10, 2010-11, 2011-12 and 2012-13); **Type of kidding-** 1 and 2 (Single and Multiple); **Sex-** 1 and 2 (Male and Female).

Figure 11. Factors affecting body length at birth of Sirohi goats



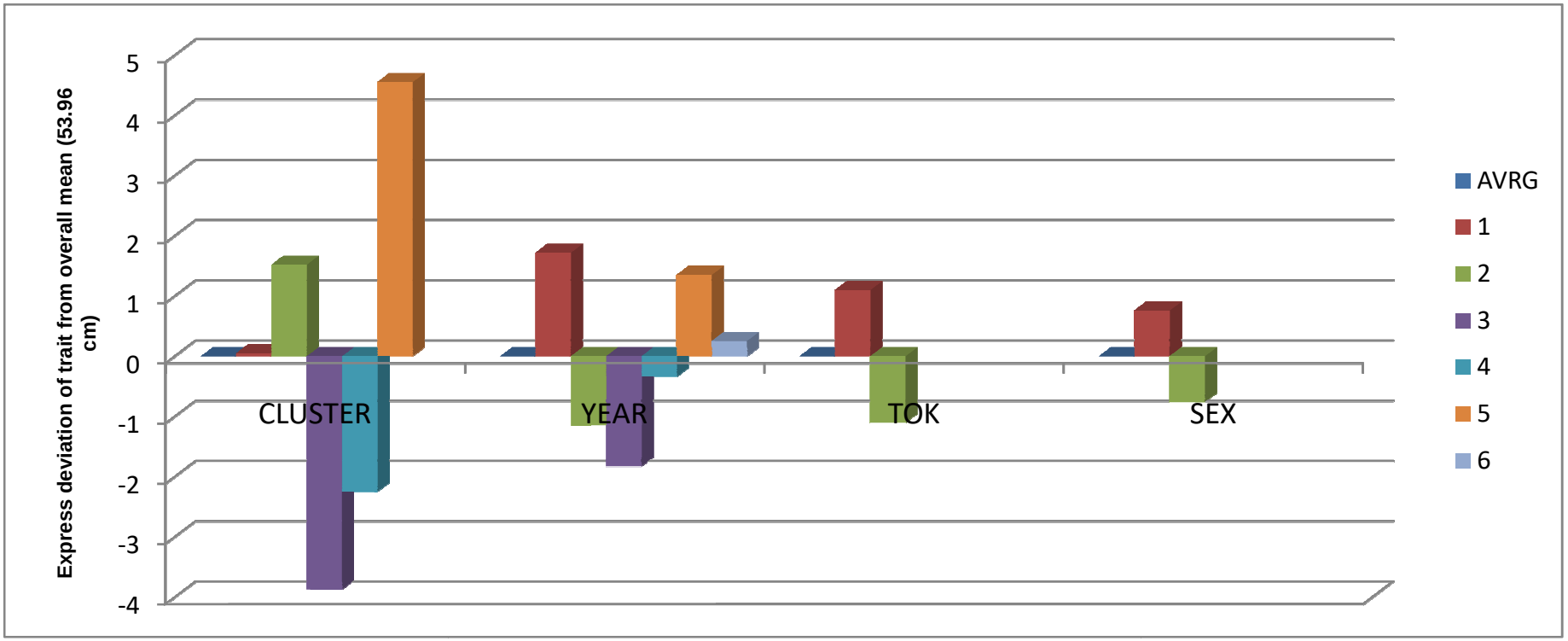
Cluster- 1 to 5 (Vallabhnagar, Railmagra, Devgarh, Nathdwara and Bhadsoda); **Season-** 1 to 3 (Rainy, Winter and Summer); **Year-** 1 to 6 (2007-08, 2008-09, 2009-10, 2010-11, 2011-12 and 2012-13); **Type of kidding-** 1 and 2 (Single and Multiple); **Sex-** 1 and 2 (Male and Female).

Figure 12. Factors affecting 3 months body length of Sirohi goats



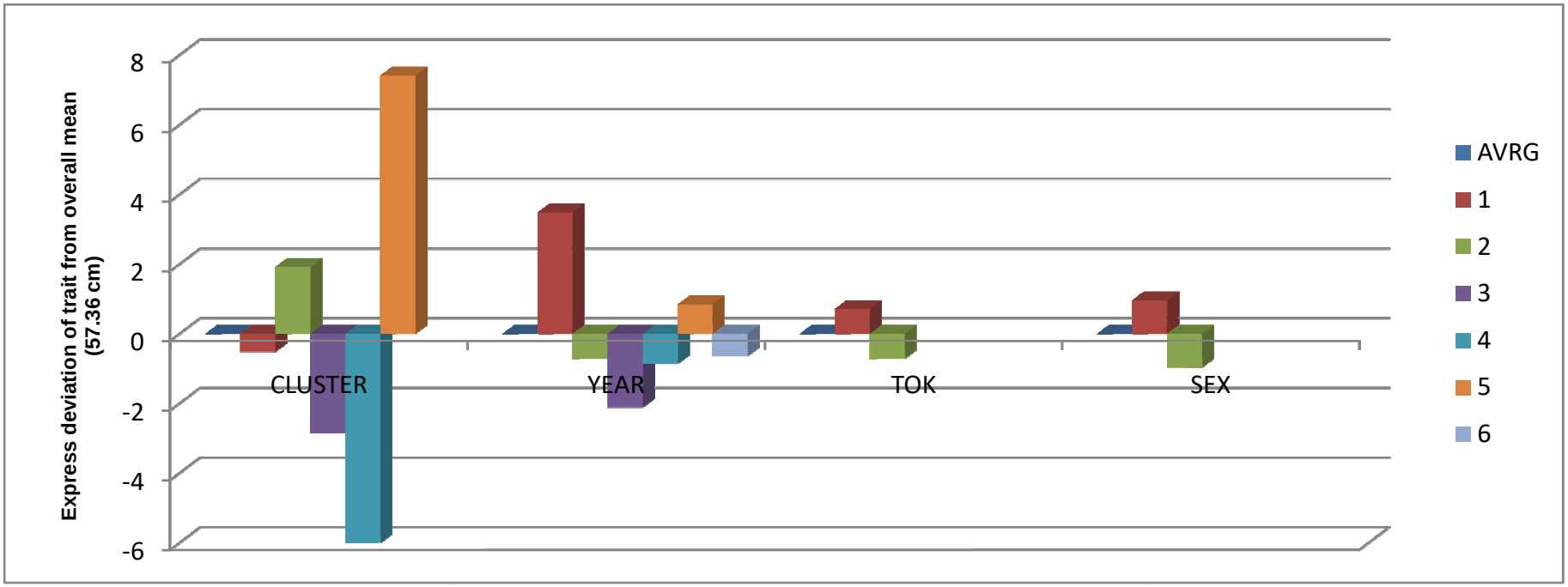
Cluster- 1 to 5 (Vallabhnagar, Railmagra, Devgarh, Nathdwara and Bhadsoda); **Season-** 1 to 3 (Rainy, Winter and Summer); **Year-** 1 to 6 (2007-08, 2008-09, 2009-10, 2010-11, 2011-12 and 2012-13); **Type of kidding-** 1 and 2 (Single and Multiple); **Sex-** 1 and 2 (Male and Female).

Figure 13. Factors affecting 6 months body length of Sirohi goats



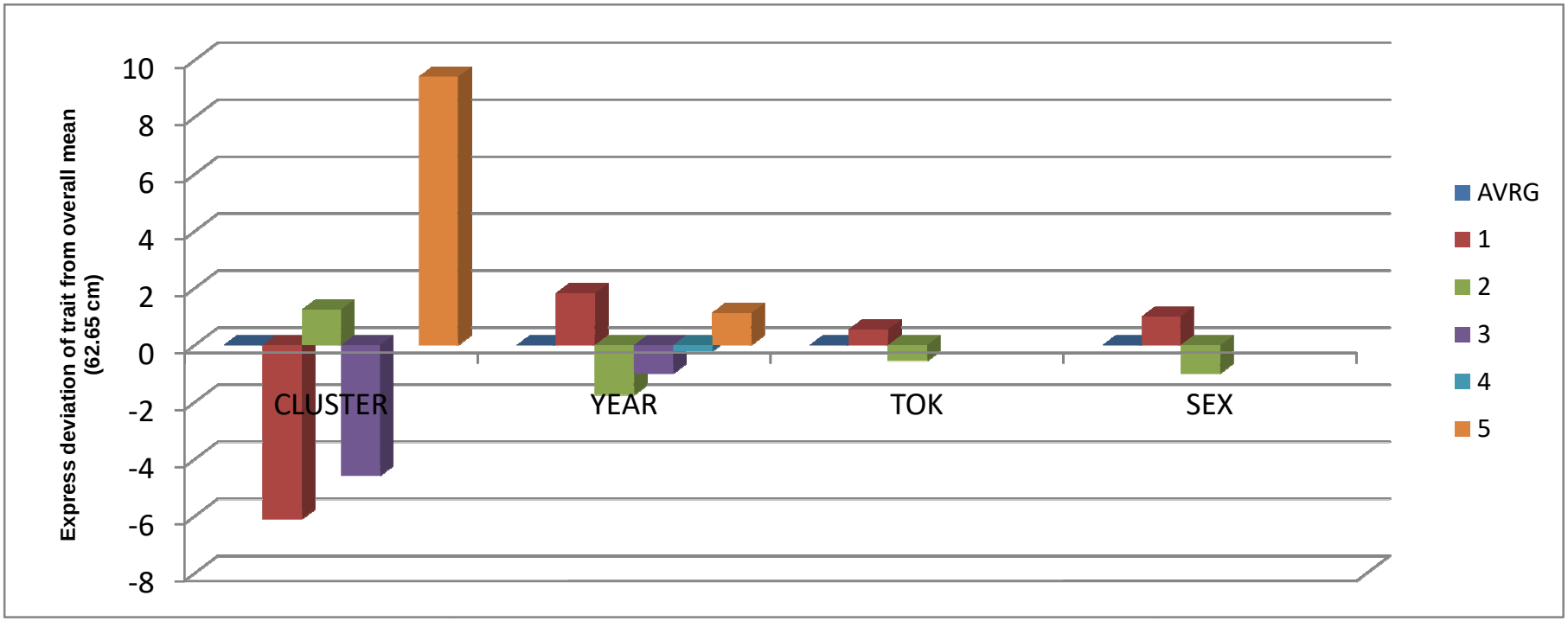
Cluster- 1 to 5 (Vallabhnagar, Railmagra, Devgarh, Nathdwara and Bhadsoda); **Year-** 1 to 6 (2007-08, 2008-09, 2009-10, 2010-11, 2011-12 and 2012-13); **Type of kidding-** 1 and 2 (Single and Multiple); **Sex-** 1 and 2 (Male and Female).

Figure 14. Factors affecting 9 months body length of Sirohi goats



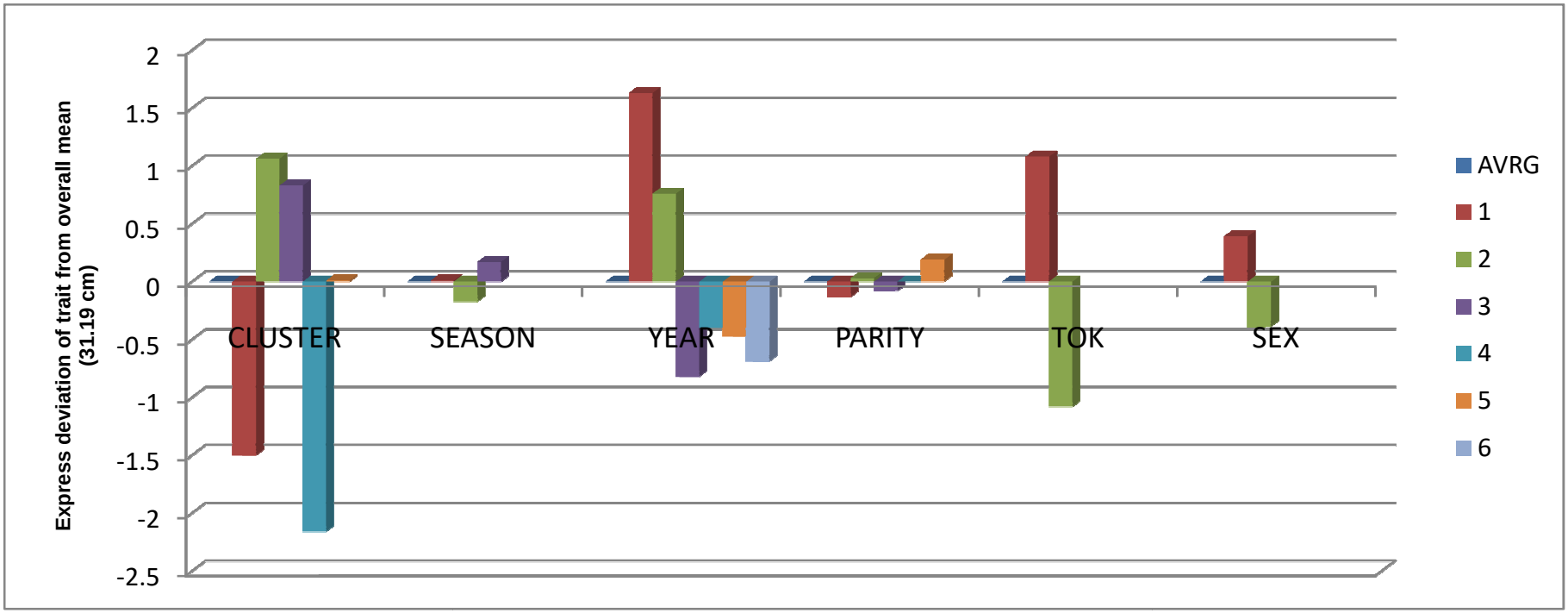
Cluster- 1 to 5 (Vallabhnagar, Railmagra, Devgarh, Nathdwara and Bhadsoda); **Year-** 1 to 6 (2007-08, 2008-09, 2009-10, 2010-11, 2011-12 and 2012-13); **Type of kidding-** 1 and 2 (Single and Multiple); **Sex-** 1 and 2 (Male and Female).

Figure 15. Factors affecting 12 months body length of Sirohi goats



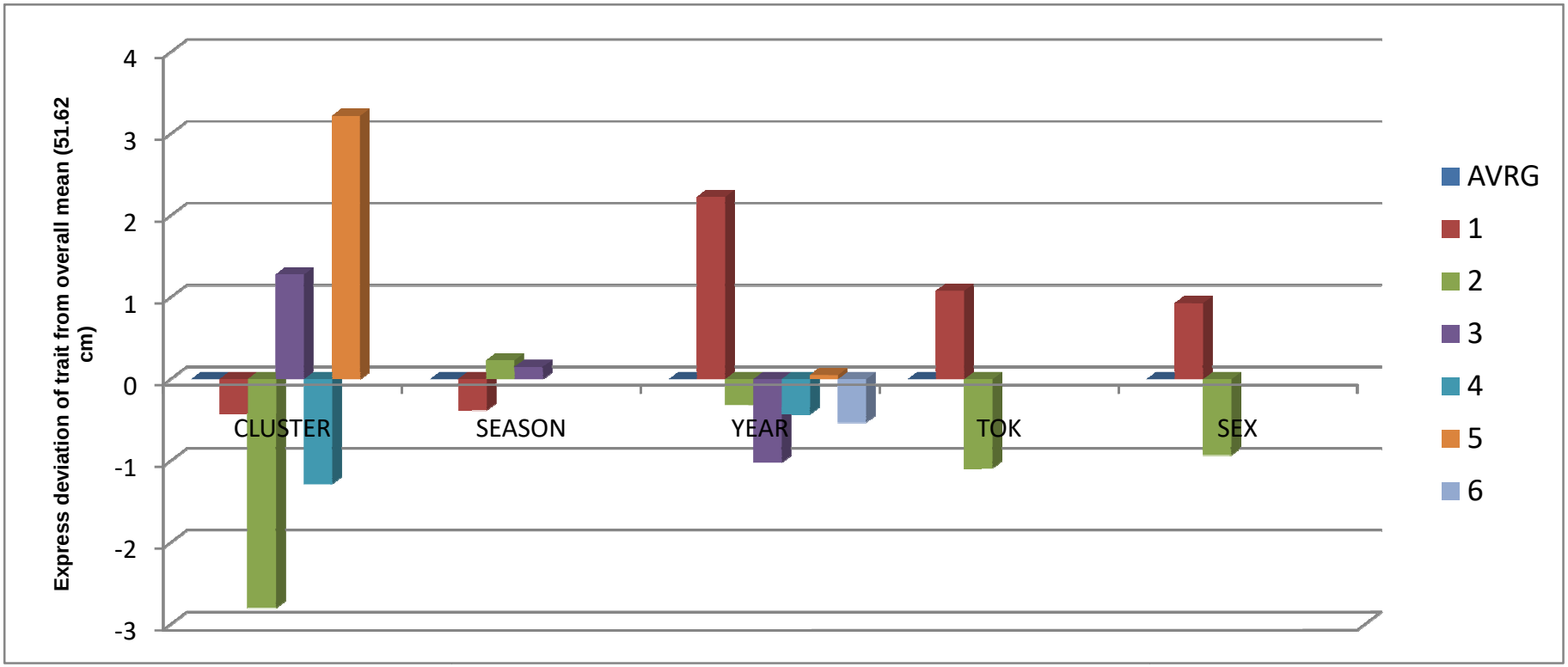
Cluster- 1 to 5 (Vallabhnagar, Railmagra, Devgarh, Nathdwara and Bhadsoda); **Year-** 1 to 6 (2007-08, 2008-09, 2009-10, 2010-11, 2011-12 and 2012-13); **Type of kidding-** 1 and 2 (Single and Multiple); **Sex-** 1 and 2 (Male and Female).

Figure 16. Factors affecting body girth at birth of Sirohi goats



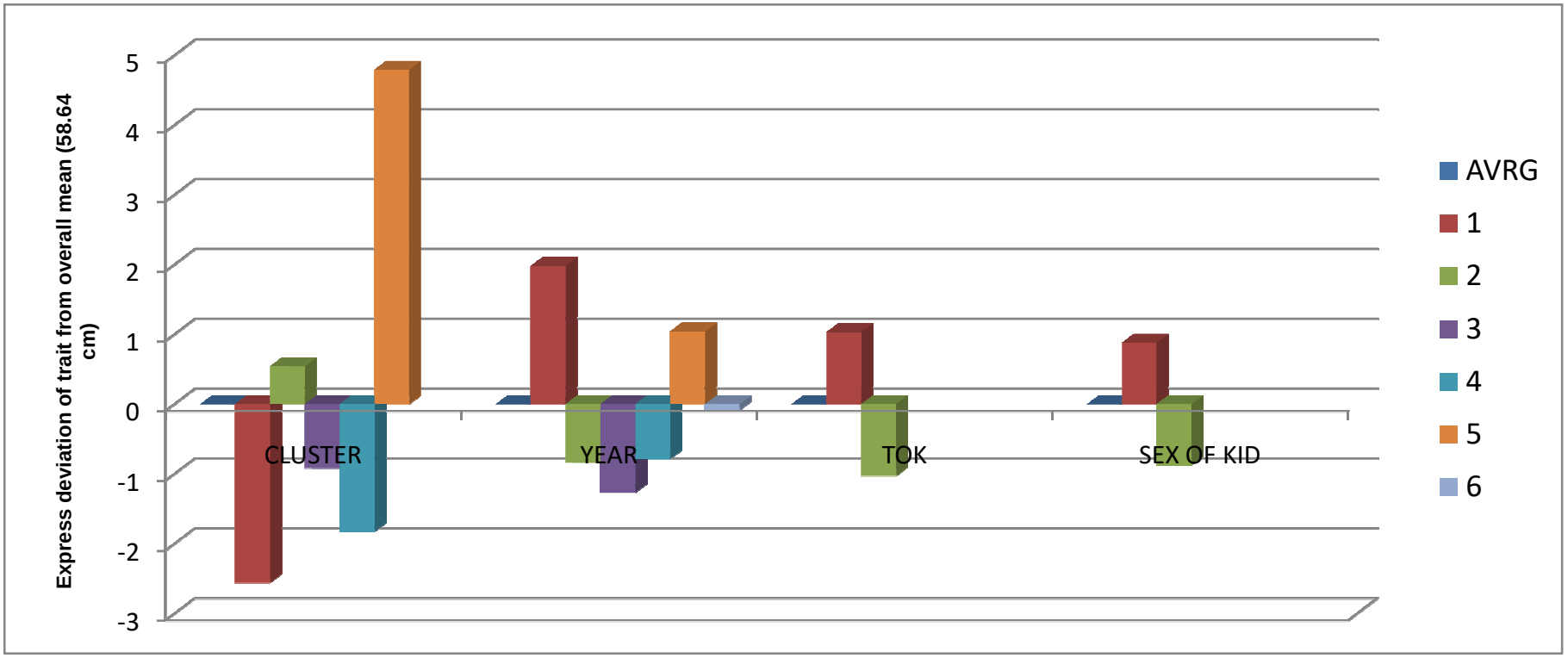
Cluster- 1 to 5 (Vallabhnagar, Railmagra, Devgarh, Nathdwara and Bhadsoda); **Season-** 1 to 3 (Rainy, Winter and Summer); **Year-** 1 to 6 (2007-08, 2008-09, 2009-10, 2010-11, 2011-12 and 2012-13); **Parity-** 1 to 5; **Type of kidding-** 1 and 2 (Single and Multiple); **Sex-** 1 and 2 (Male and Female).

Figure 17. Factors affecting 3 months body girth of Sirohi goats



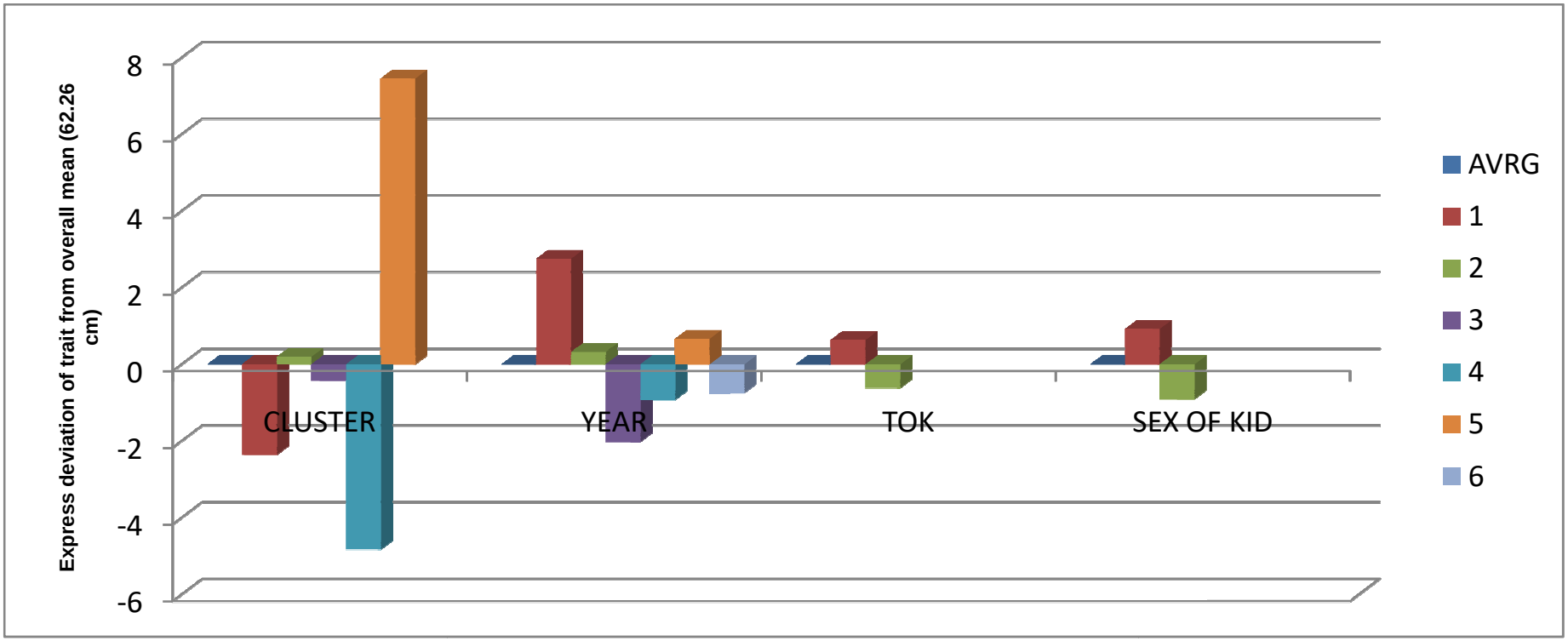
Cluster- 1 to 5 (Vallabhnagar, Railmagra, Devgarh, Nathdwara and Bhadsoda); **Season-** 1 to 3 (Rainy, Winter and Summer); **Year-** 1 to 6 (2007-08, 2008-09, 2009-10, 2010-11, 2011-12 and 2012-13); **Type of kidding-** 1 and 2 (Single and Multiple); **Sex-** 1 and 2 (Male and Female).

Figure 18. Factors affecting 6 months body girth of Sirohi goats



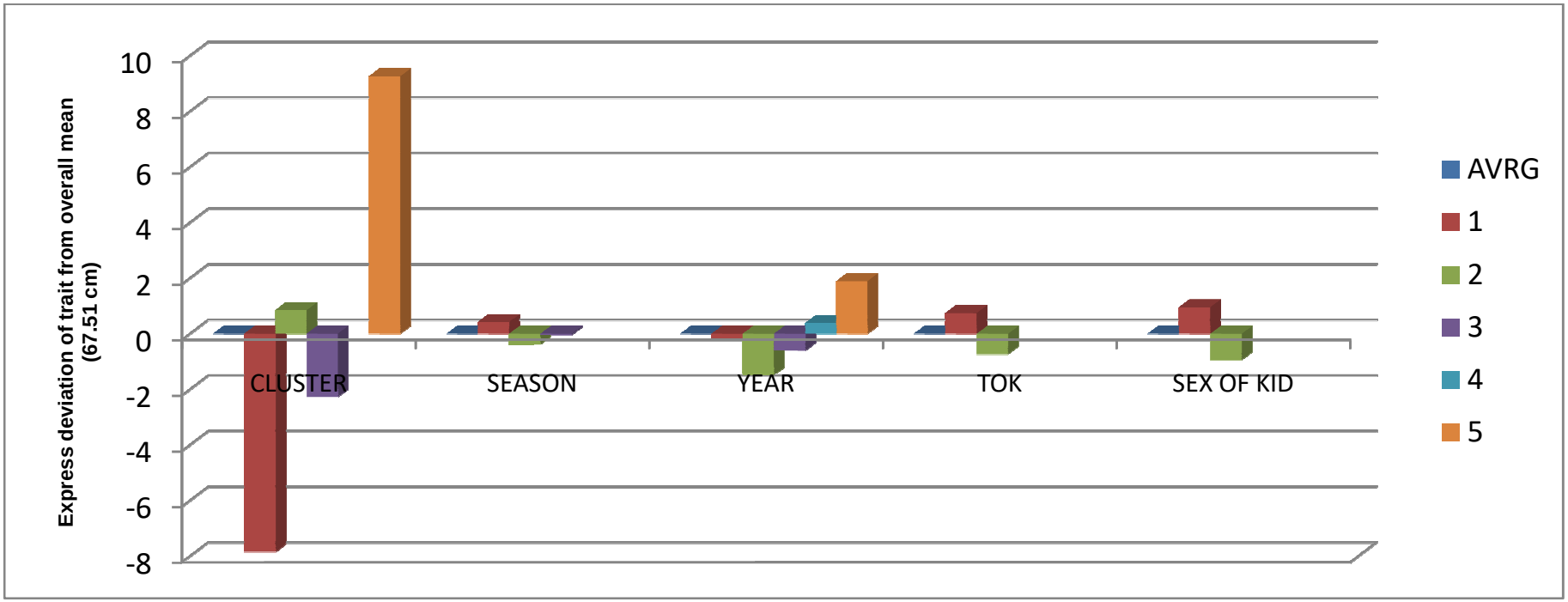
Cluster- 1 to 5 (Vallabhnagar, Railmagra, Devgarh, Nathdwara and Bhadsoda); **Year-** 1 to 6 (2007-08, 2008-09, 2009-10, 2010-11, 2011-12 and 2012-13); **Type of kidding-** 1 and 2 (Single and Multiple); **Sex-** 1 and 2 (Male and Female).

Figure 19. Factors affecting 9 months body girth of Sirohi goats



Cluster- 1 to 5 (Vallabhnagar, Railmagra, Devgarh, Nathdwara and Bhadsoda); **Year-** 1 to 6 (2007-08, 2008-09, 2009-10, 2010-11, 2011-12 and 2012-13); **Type of kidding-** 1 and 2 (Single and Multiple); **Sex-** 1 and 2 (Male and Female).

Figure 20. Factors affecting 12 months body girth of Sirohi goats



Cluster- 1 to 5 (Vallabhnagar, Railmagra, Devgarh, Nathdwara and Bhadsoda); **Season-** 1 to 3 (Rainy, Winter and Summer); **Year-** 1 to 6 (2007-08, 2008-09, 2009-10, 2010-11, 2011-12 and 2012-13); **Type of kidding-** 1 and 2 (Single and Multiple); **Sex-** 1 and 2 (Male and Female).

4.6 Genetic and phenotypic parameters for Morphometric traits at different ages

The results regarding estimated genetic and phenotypic parameters *viz*. heritability, genetic and phenotypic correlations of a population are presented in Table 4.10, 4.11 and 4.12.

4.6.1 Heritability

The heritability estimates for morphometric traits under study were of high magnitude. The heritability estimates for morphometric traits ranged between 0.528 ± 0.163 to 0.709 ± 0.144 for body height, 0.408 ± 0.159 to 0.605 ± 0.192 for body length and 0.503 ± 0.197 to 0.695 ± 0.161 for body girth. Higher estimates were also reported by Tomar *et al.* (2001) at 3 and 6 months of age and Pathodiya *et al.* (2004) at birth in Sirohi goats. On the other hand low heritability for body length and body height at 3 months and moderate heritability for morphometric traits at birth in Sirohi goats were reported by Tomar *et al.* (2001). The results indicated the presence of additive genetic variability and hence mass selection would be effective to improve these traits.

4.6.2 Genetic correlations

Estimates of genetic correlations between body heights at different ages ranged from 0.520 ± 0.030 for 6BH -9BH to 0.775 ± 0.014 for 9BH – 12BH. The genetic correlations of body height at birth with body height at 3, 6, 9 and 12 months of age were estimated as 0.621 ± 0.059, 0.533 ± 0.102, 0.636 ± 0.080 and 0.767 ± 0.074, respectively. The genetic correlation of three months body height with body height at 6, 9 and 12 months of age were estimated as 0.664 ± 0.046, 0.691 ± 0.040 and0.513 ± 0.036, respectively. The genetic correlation of six months body height with body height at 9 and 12 months of age were estimated as 0.520 ± 0.030 and 0.664 ± 0.049, respectively. The genetic correlation of body height at 9 months of age with that of 12 months body height was found to be positive and high as 0.775 ± 0.014.

Estimates of genetic correlations between body lengths at different ages ranged from 0.478 ± 0.126 for BBL -6BL to 0.863 ± 0.050 for 6BL – 12BL. The genetic correlations of body length at birth with body length at 3, 6, 9 and 12 months of age were estimated as 0.584 ± 0.069, 0.478 ± 0.126, 0.576 ± 0.109 and 0.679 ± 0.090, respectively. The genetic correlation of three months body length with body length at 6, 9 and 12 months of age were estimated as 0.660 ± 0.050, 0.550 ± 0.0 and 0.648 ± 0.030, respectively. The genetic correlation of six months body length with body length at 9 and 12 months of age were estimated as 0.731 ± 0.028 and 0.863 ± 0.050, respectively. The genetic correlation of body length at 9 months of age with that of 12 months body length was found to be positive and high as 0.835 ± 0.026.

Estimates of genetic correlations between body girths at different ages ranged from 0.508 ± 0.061 for BBG - 9BG to 0.900 ± 0.044 for 6BG – 12BG. The genetic correlations of body girth at birth with body girth at 3, 6, 9 and 12 months of age were estimated as 0.519 ± 0.058, 0.620 ± 0.088, 0.508 ± 0.061 and 0.608 ± 0.061, respectively. The genetic correlation of three months body girth with body girth at 6, 9 and 12 months of age were estimated as 0.582 ± 0.047, 0.611 ± 0.035 and 0.591 ± 0.041, respectively. The genetic correlation of six months body girth with body girth at 9 and 12 months of age were estimated as 0.667 ± 0.023 and 0.900 ± 0.044, respectively. The genetic correlation of body girth at 9 months of age with that of 12 months body girth was found to be positive and high as 0.863 ± 0.017.

Table No. 4.10. Estimates of heritability (on diagonal), genetic correlation (above diagonal) and phenotypic correlation (below diagonal) among body height at different ages in Sirohi goats.

Trait	BBH	3 BH	6 BH	9 BH	12 BH
BBH	**0.693 ± 0.130**	0.621 ± 0.059	0.533 ± 0.102	0.636 ± 0.080	0.767 ± 0.074
3 BH	0.443 ± 0.024	**0.528 ± 0.163**	0.664 ± 0.046	0.691 ± 0.040	0.513 ± 0.036
6 BH	0.354 ± 0.026	0.658 ± 0.017	**0.709 ± 0.144**	0.520 ± 0.030	0.664 ± 0.049
9 BH	0.357 ± 0.026	0.573 ± 0.020	0.727 ± 0.014	**0.699 ± 0.179**	0.775 ± 0.014
12 BH	0.333 ± 0.026	0.495 ± 0.022	0.557 ± 0.020	0.741 ± 0 .013	**0.708 ± 0.188**

Note: BBH= Body height at birth, 3 BH= 3 months body height, 6 BH= 6 months body height, 9 BH= 9 months body height, 12 BH= 12 months body height. Phenotypic correlations are highly significant tested by't' test.

4.6.2 Phenotypic correlations

Phenotypic correlation is the association between phenotypic values of different traits measured on the same animal. It is a joint function of the genotype, and environment and interaction if any, between the two, but their relative contributions are varied. The estimates of phenotypic correlations between different

Table No. 4.11. Estimates of heritability (on diagonal), genetic correlation (above diagonal) and phenotypic correlation (below diagonal) among body length at different ages in Sirohi goats.

Trait	BBL	3 BL	6 BL	9 BL	12 BL
BBL	**0.568 ± 0 .137**	0.584 ± 0.069	0.478 ± 0.126	0.576 ± 0.109	0.679 ± 0.090
3 BL	0.373 ± 0.025	**0.408 ± 0.159**	0.660 ± 0.050	0.550 ± 0.052	0.648 ± 0.030
6 BL	0.227 ± 0.028	0.555 ± 0.020	**0.589 ± 0.150**	0.731 ± 0.028	0.863 ± 0.050
9 BL	0.261 ± 0.028	0.513 ± 0.022	0.703 ± 0.015	**0.571 ± 0.172**	0.835 ± 0.026
12 BL	0.294 ± 0.027	0.458 ± 0.023	0.520 ± 0.022	0.663 ± 0 .017	**0.605 ± 0.192**

Note: BBL= Body length at birth, 3 BL= 3 months body length, 6 BL= 6 months body length, 9 BL= 9 months body length, 12 BL= 12 months body length. Phenotypic correlations are highly significant tested by't' test.

Table No. 4.12. Estimates of heritability (on diagonal), genetic correlation (above diagonal) and phenotypic correlation (below diagonal) among body girth at different ages in Sirohi goats.

Trait	BBG	3 BG	6 BG	9 BG	12 BG
BBG	**0.590 ± 0.147**	0.519 ± 0.058	0.620 ± 0.088	0.508 ± 0.061	0.608 ± 0.061
3 BG	0.465 ± 0.023	**0.695 ± 0.161**	0.582 ± 0.047	0.611 ± 0.035	0.591 ± 0.041
6 BG	0.340 ± 0.026	0.559 ± 0.020	**0.563 ± 0.138**	0.667 ± 0.023	0.900 ± 0.044
9 BG	0.418 ± 0.024	0.573 ± 0.020	0.645 ± 0.017	**0.676 ± 0.184**	0.863 ± 0.017
12 BG	0.394 ± 0.025	0.506 ± 0.022	0.497 ± 0.022	0.668 ± 0 .017	**0.503 ± 0.197**

Note: BBG= Body girth at birth, 3 BG= 3 months body girth, 6 BG= 6 months body girth, 9 BG= 9 months body girth, 12 BG= 12 months body girth. Phenotypic correlations are highly significant tested by't' test.

morphometric traits at different ages are presented in table 4.10, 4.11 and 4.12 and are discussed as follows.

Phenotypic correlations between body heights at different ages ranged from 0.333 ± 0.026 for BBH-12BH to 0.741 ± 0.013 for 9BH-12BH. The phenotypic correlations of body height at birth with body height at 3, 6, 9 and 12 months of age were estimated as 0.443 ± 0.024, 0.354 ± 0.026, 0.357 ± 0.026 and 0.333 ± 0.026, respectively. The phenotypic correlation of three months body height with body height at 6, 9 and 12 months of age were estimated as 0.658 ± 0.017, 0.573 ± 0.020 and 0.495 ± 0.022, respectively. The phenotypic correlation of six months body height with body height at 9 and 12 months of age were estimated as 0.727 ± 0.014 and 0.557 ± 0.020, respectively. The phenotypic correlation of body height at 9 months of age with that of 12 months body height was found to be positive and high as 0.741 ± 0.013.

Phenotypic correlations between body lengths at different ages ranged from 0.227 ± 0.028 for BBL - 6BL to 0.703 ± 0.015 for 6BL – 9BL. The phenotypic correlations of body length at birth with body length at 3, 6, 9 and 12 months of age were estimated as 0.373 ±

0.025, 0.227 ± 0.028, 0.261 ± 0.028 and 0.294 ± 0.027, respectively. The phenotypic correlation of three months body length with body length at 6, 9 and 12 months of age were estimated as 0.555 ± 0.020, 0.513 ± 0.022 and 0.458 ± 0.023, respectively. The phenotypic correlation of six months body length with body length at 9 and 12 months of age were estimated as 0.703 ± 0.015 and 0.520 ± 0.022, respectively. The phenotypic correlation of body length at 9 months of age with that of 12 months body length was found to be positive and high as 0.663 ± 0.017.

Phenotypic correlations between body girths at different ages ranged from 0.340 ± 0.026 for BBG - 6BG to 0.668 ± 0.017 for 9BG – 12BG. The phenotypic correlations of body girth at birth with body girth at 3, 6, 9 and 12 months of age were estimated as 0.465 ± 0.023, 0.340 ± 0.026, 0.418 ± 0.024 and 0.394 ± 0.025, respectively. The phenotypic correlation of three months body girth with body girth at 6, 9 and 12 months of age were estimated as 0.559 ± 0.020, 0.573 ± 0.020 and 0.506 ± 0.022, respectively. The phenotypic correlation of six months body girth with body girth at 9 and 12 months of age were estimated as 0.645 ± 0.017 and 0.497 ± 0.022, respectively. The phenotypic correlation of body girth at 9 months of age with that of 12 months body girth was found to be positive and high as 0.668 ± 0.017.

4.7 Production performance and factors affecting it.

The overall least squares means for production traits have been presented in table 4.14.

The overall least squares means for test days milk yield was estimated as 0.604 ± 0.02 litres.

The overall least squares means for 90 days milk yield was estimated as 61.79 ± 2.48 litres. Gurjar *et al.* (2005) reported lower estimates of 90 days milk yield as 44.89±0.77 litres in Sirohi goats. The higher estimates of 90 days milk yield as 69.13 ± 4.01 kg reported by Kumar *et al.* (2006) in Kutchi goats, Singh and Ramachandran (2007)

reported as 71.46±5.33 l litres in Sirohi goats, Deshpande *et al.* (2009) as 94.29 ± 2.88 kg in Surti goats and Tyagi *et al.* (2013) as 110.70 ± 1.10 litres in Surti goats.

The overall least squares means for 150 days milk yield was estimated as 90.96 ± 2.58 litres. Gurjar *et al.* (2005) reported lower estimates of 150 days milk yield as 66.33±1.41 litres in Sirohi goats, Yadav and Khada (2009) reported as 62.29 ± 2.59 litres in crossbred of local x Sirohi goats, Pathodiya *et al.* (2010) reported as 56.34 ± 2.93 litres in Sirohi goats. The higher estimates of 150 days milk yield as, 94.72±5.10 kg reported by Kumar *et al.* (2006) in Kutchi goats, Singh and Ramachandran (2007) reported as 98.63±7.74 litres in Sirohi goats, Deshpande *et al.* (2009) reported as 138.19 ± 4.05 kg in Surti goat, Tyagi *et al.* (2013) repoted as 166.08 ± 1.64 litres in Surti goats.

The average total milk yield was estimated as 91.08 ± 2.56 litres. The higher total milk yield estimates of 114.22 ± 22.62 kg in nondescript and graded Sirohi by Gokhale *et al.,* (1997), 152.87 ± 2.69 kg in semi intensive system and 107.39±0.11 kg in extensive system of management of Jakhrana goats by Rai and Singh (2005), 112.56±5.65 kg in Kutchi goats by Kumar *et al.* (2006), 117.66±14.94 litres in Sirohi goats by Singh and Ramachandran (2007), 273.95±1.08 litres in Surti goats by

Table 4.13 Least squares analysis of variance for various factors affecting production traits in Sirohi goats

SOURCE OF VARIATION	ATDMY		90 DMY		150 DMY		TMY		LL		DP	
	D.F.	M.S.	D.F.	M.S.	D.F.	M.S.	D.F.	M.S.	D.F.	M.S.	D.F.	M.S.
Sire	93	0.039**	93	517.10**	89	546.80**	89	540.96**	89	44.31**	89	17576.97**
Cluster	4	0.776**	4	10205.04**	4	14147.53**	4	14333.10**	4	90.97**	4	25289.16**
Season	2	0.284**	2	643.17**	2	765.15**	2	660.38*	2	202.97**	2	9701.99
Year	5	0.177**	5	985.65**	5	707.04**	5	599.40**	5	176.94**	5	41020.19**
Parity	4	0.544**	4	7189.21**	4	12250.94**	4	12601.77**	4	28.97	4	23430.97**
Type of birth	1	0.031	1	486.87*	1	102.81	1	76.03	1	18.02	1	6095.67
Reg. on DWK	1	0.389**	1	64.94**	1	118.35**	1	103.98**	1	37.35	1	1762.63**
Error	1781	0.008	1780	113.172391	1297	151.875250	1297	154.502367	1297	15.112130	1276	6951.547351

Note : ATDMY= Average test day milk yield, 90 DMY= 90 Days milk yield, 150 DMY= 150 Days milk yield, TMY= Total milk yield, LL= Lactation length, DP= Dry period. D.F. =Degree of freedom, M.S.= Mean squares, Reg. on DWK = Regression on weight of dam at kidding. ** = Highly significant (P≤0.01), *= Significant (P≤0.05).

Table No. 4.14. Least-squares means and S.E. for milk production (lit.) of Sirohi goat

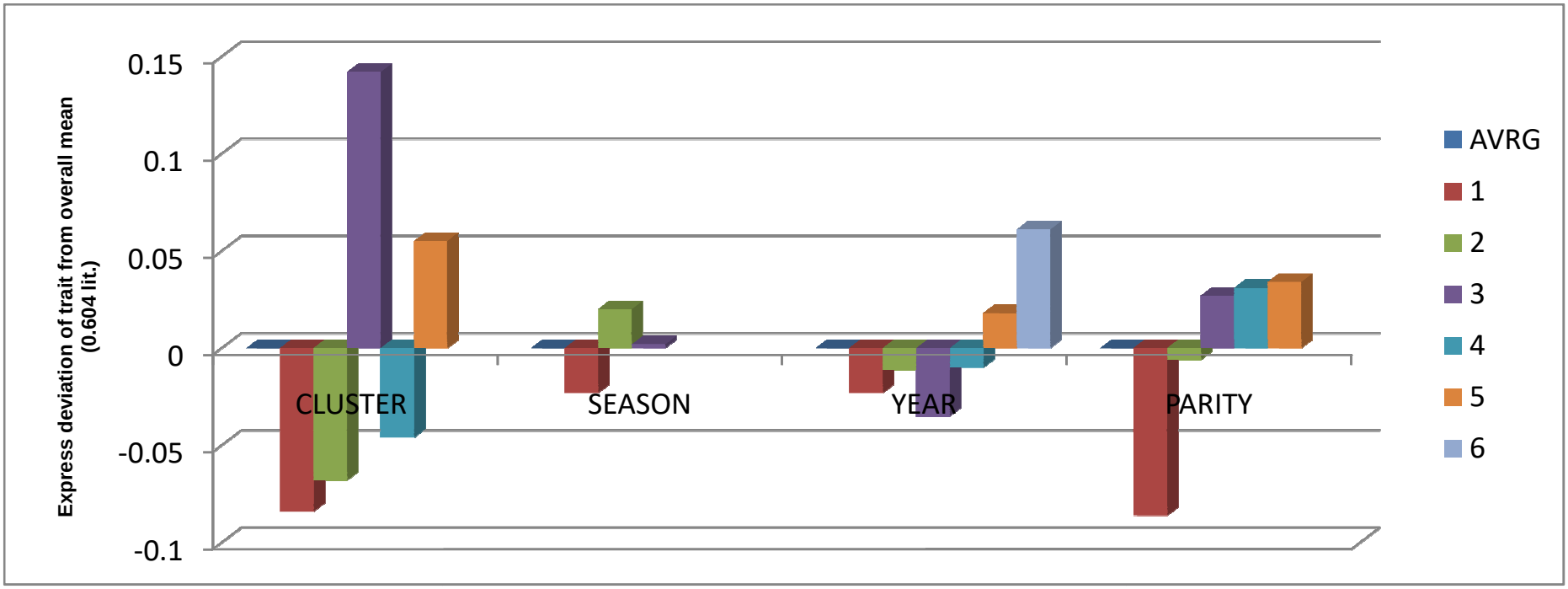
Traits / Factors	Average Test Day M. Y.	90 Days M. Y.	150 Days M. Y.	Total M. Y.	Lactation Length (Days)	Dry Period (Days)
Overall mean (μ)	0.604 ± 0.02 (1892)	61.79 ± 2.48 (1892)	90.96 ± 2.58 (1405)	91.08 ± 2.56 (1405)	150.75 ± 0.72 (1405)	151.63 ± 14.25 (1384)
Sire	**	**	**	**	**	**
Cluster	**	**	**	**	**	**
Vallabhnagar	0.520 ± 0.03^{a} (29)	49.48 ± 3.61^{a} (29)	78.09 ± 4.14^{a} (27)	78.92 ± 4.14^{a} (27)	149.47 ± 1.24^{a} (27)	100.18 ± 26.24^{a} (27)
Railmagra	0.536 ± 0.02^{a} (302)	55.65 ± 2.76^{b} (302)	82.94 ± 3.04^{b} (244)	83.16 ± 3.03^{a} (244)	153.31± 0.88^{b} (244)	117.72 ± 17.98^{a} (244)
Devgarh	0.746 ± 0.49^{d} (1114)	78.85 ± 2.60^{d} (1114)	114.21 ± 2.77^{d} (914)	114.53 ± 2.75^{d} (914)	150.74 ± 0.78^{ba} (914)	251.64 ± 15.80^{c} (893)
Nathdwara	0.558 ± 0.04^{b} (15)	59.38 ± 4.82^{b} (15)	86.44 ± 5.71^{b} (13)	87.56 ± 5.74^{ba} (13)	147.10 ± 1.76^{a} (13)	127.00 ± 37.45^{ab} (13)
Bhadsoda	0.659 ± 0.02^{c} (432)	65.60 ± 2.89^{c} (432)	93.10 ± 3.28^{cb} (207)	94.22 ± 3.28^{cb} (207)	153.10 ± 0.96^{b} (207)	161.60 ± 19.82^{b} (207)
Season	**	**	**	*	**	NS
Rainy	0.581 ± 0.02^{a} (666)	60.61 ± 2.50^{a} (666)	89.35 ± 2.62^{a} (543)	89.49 ± 2.60^{a} (543)	150.87 ± 0.73^{b} (543)	145.24 ± 14.59 (537)
Winter	0.624 ± 0.02^{b} (961)	62.65 ± 2.49^{ba} (961)	90.71 ± 2.63^{a} (646)	91.12 ± 2.61^{b} (646)	151.55 ± 0.73^{c} (646)	153.67 ± 14.61 (635)
Summer	0.606 ± 0.02^{a} (265)	62.11 ± 2.55^{b} (265)	92.80 ± 2.70^{b} (216)	92.62 ± 2.68^{b} (216)	149.82 ± 0.76^{a} (216)	155.97 ± 15.22 (212)

Year of birth	**	**	**	**	**	**
2007-08	0.581 ± 0.02^{a} (226)	57.95 ± 2.59^{a} (226)	88.92 ± 2.76^{a} (213)	89.93 ± 2.75^{a} (213)	153.31 ± 0.78^{c} (213)	126.08 ± 15.76^{a} (208)
2008-09	0.593 ± 0.02^{cd} (221)	60.94 ± 2.61^{b} (221)	90.27 ± 2.79^{ab} (193)	90.32 ± 2.77^{a} (193)	150.52 ± 0.79^{ba} (193)	130.39 ± 15.96^{a} (189)
2009-10	0.569 ± 0.02^{e} (234)	61.27 ± 2.60^{b} (234)	88.32 ± 2.80^{a} (165)	88.30 ± 2.78^{a} (165)	150.63 ± 0.79^{ba} (165)	143.16 ± 16.05^{a} (157)
2010-2011	0.594 ± 0.02^{bc} (381)	61.26 ± 2.56^{b} (381)	90.03 ± 2.70^{a} (318)	90.29 ± 2.69^{a} (318)	150.52 ± 0.75^{b} (318)	179.06 ± 15.25^{c} (314)
2011-2012	0.622 ± 0.02^{ab} (399)	62.99 ± 2.57^{c} (399)	92.25 ± 2.74^{b} (269)	91.99 ± 2.72^{ba} (269)	149.87 ± 0.77^{a} (269)	161.11 ± 15.51^{b} (269)
2012-2013	0.665 ± 0.02^{de} (431)	66.34 ± 2.59^{d} (431)	95.96 ± 2.83^{c} (247)	95.62 ± 2.82^{b} (247)	149.56 ± 0.81^{a} (247)	169.98 ± 16.31^{bc} (247)
Parity	**	**	**	**	NS	**
1st	0.518 ± 0.02^{a} (573)	51.87 ± 2.54^{a} (573)	75.43 ± 2.70^{a} (417)	75.33 ± 2.68^{a} (417)	150.16 ± 0.76 (417)	86.57 ± 15.21^{a} (415)
2nd	0.598 ± 0.02^{b} (434)	61.17 ± 2.52^{b} (434)	89.91 ± 2.66^{b} (349)	90.06 ± 2.64^{b} (349)	150.88 ± 0.74 (349)	133.05 ± 14.85^{b} (348)
3rd	0.631 ± 0.02^{c} (332)	65.12 ± 2.53^{c} (332)	96.24 ± 2.68^{c} (264)	96.39 ± 2.66^{c} (264)	150.68 ± 0.75 (264)	172.46 ±15.06^{c} (257)
4th	0.635 ± 0.02^{c} (239)	65.30 ±2.56^{c} (239)	97.59 ± 2.75^{c} (176)	97.85 ± 2.73^{c} (176)	151.29 ± 0.77 (176)	193.94 ± 15.60^{d} (171)
≥ 5th	0.638 ± 0.02^{c} (314)	65.50 ± 2.58^{c} (314)	95.63 ± 2.79^{c} (199)	95.75 ± 2.78^{c} (199)	150.72 ± 0.79 (199)	172.11 ± 16.02^{c} (193)
Type of birth	NS	*	NS	NS	NS	NS
Single	0.609 ± 0.02^{b} (1454)	62.48 ± 2.48^{b} (1454)	91.34 ± 2.58 (1108)	91.40 ± 2.56 (1108)	150.59 ± 0.72 (1108)	154.58 ± 14.22 (1093)
Multiple	0.598 ± 0.02^{a} (438)	61.11 ± 2.52^{a} (438)	90.58 ± 2.67 (297)	90.75 ± 2.65 (297)	150.90 ± 0.75 (297)	148.68 ±14.96 (291)

Regression on weight of dam at kidding	**	**	**	**	NS	**
Regression coefficient (b) (kg/kg)	0.0089± 0.0013	1.23 ± 0.15	0.80 ± 0.21	0.76 ± 0.21	0.10 ± 0.06	4.55 ±1.44

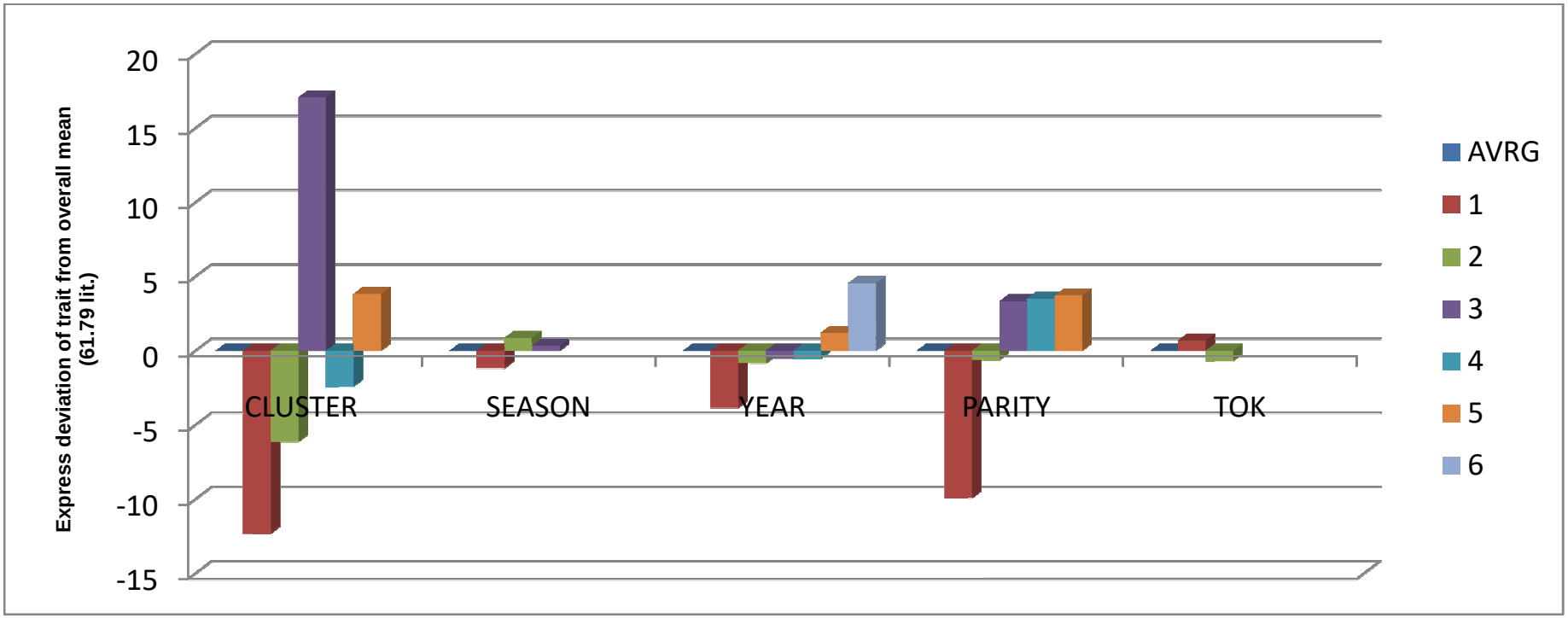
NOTE: No. of observations are given in parentheses. Estimates with different superscripts differ significantly. ** = Highly significant (P≤0.01), * = Significant (P≤0.05), NS = Non-significant

Figure 21. Factors affecting average test day milk yield of Sirohi goats



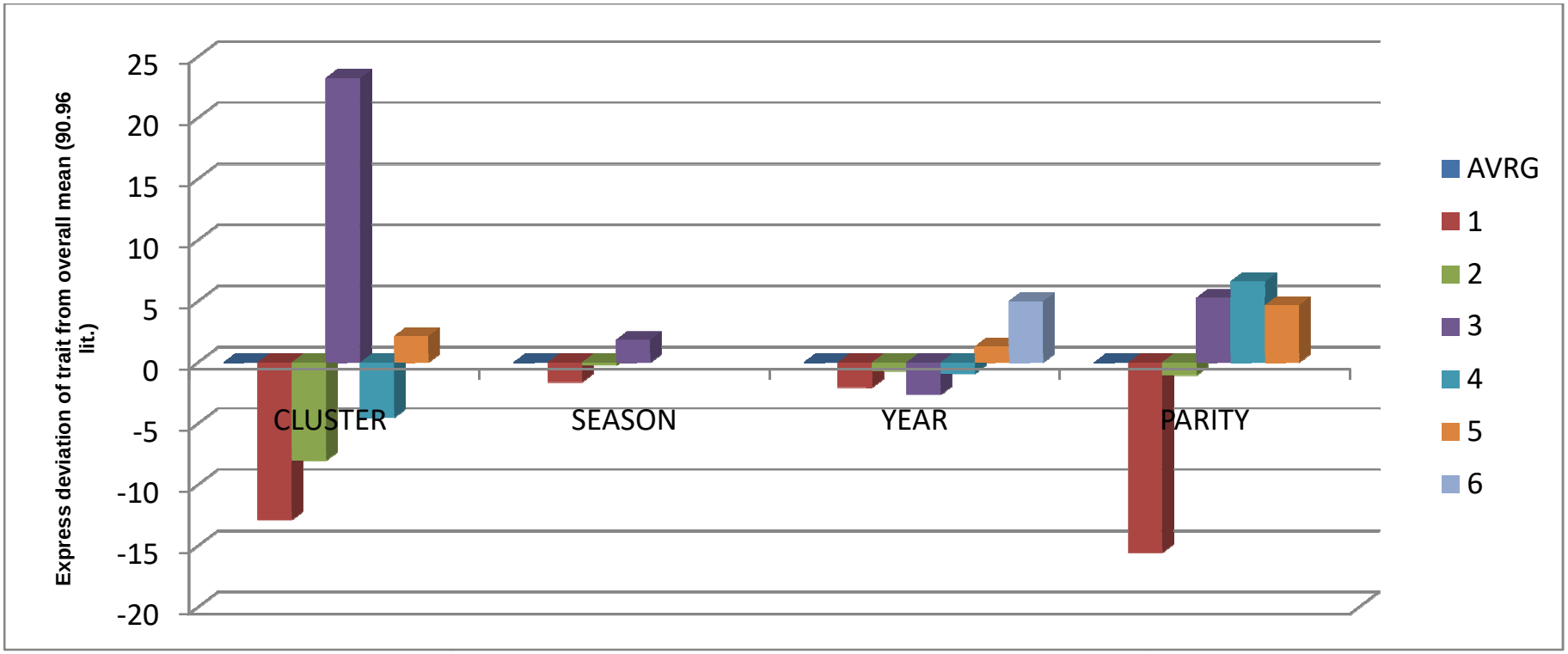
Cluster- 1 to 5 (Vallabhnagar, Railmagra, Devgarh, Nathdwara and Bhadsoda); **Season-** 1 to 3 (Rainy, Winter and Summer); **Year-** 1 to 6 (2007-08, 2008-09, 2009-10, 2010-11, 2011-12 and 2012-13); **Parity-** (1 to 5).

Figure 22. Factors affecting 90 days milk yield of Sirohi goats



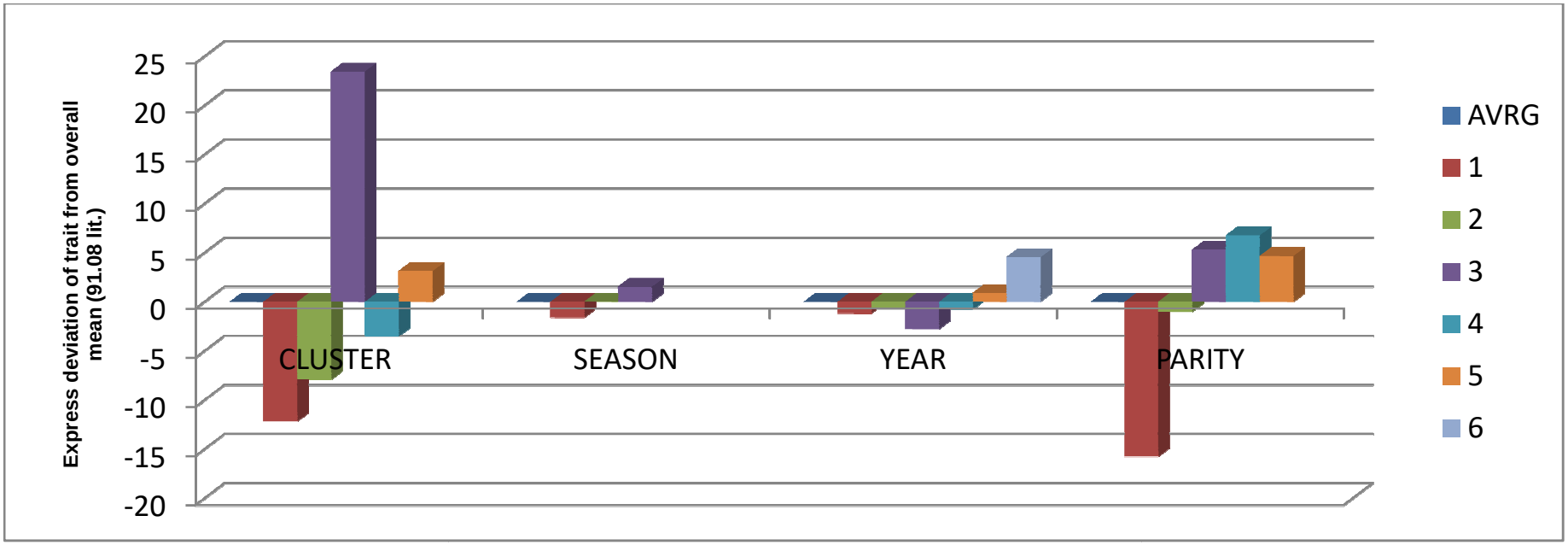
Cluster- 1 to 5 (Vallabhnagar, Railmagra, Devgarh, Nathdwara and Bhadsoda); **Season-** 1 to 3 (Rainy, Winter and Summer); **Year-** 1 to 6 (2007-08, 2008-09, 2009-10, 2010-11, 2011-12 and 2012-13); **Parity-** (1 to 5); **Type of kidding-** 1 and 2 (Single and Multiple).

Figure 23. Factors affecting 150 days milk yield of Sirohi goats



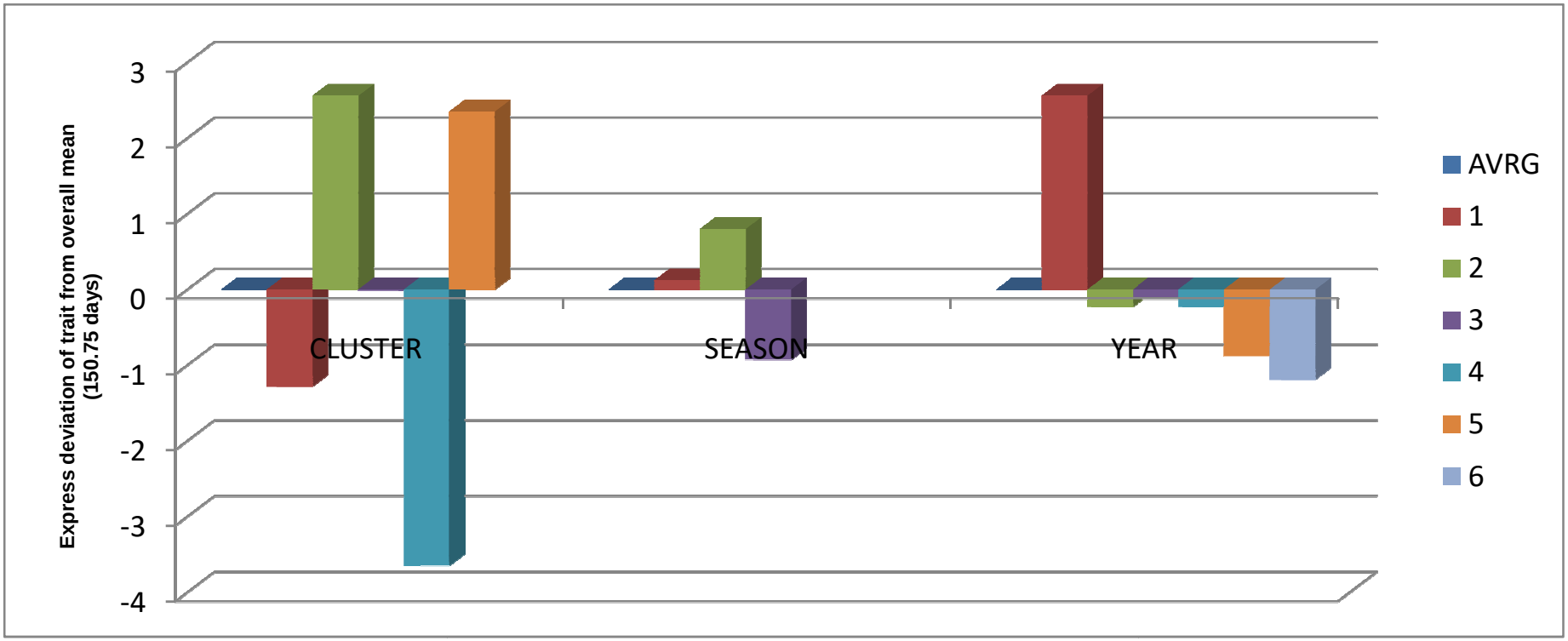
Cluster- 1 to 5 (Vallabhnagar, Railmagra, Devgarh, Nathdwara and Bhadsoda); **Season-** 1 to 3 (Rainy, Winter and Summer); **Year-** 1 to 6 (2007-08, 2008-09, 2009-10, 2010-11, 2011-12 and 2012-13); **Parity-** (1 to 5).

Figure 24. Factors affecting total milk yield of Sirohi goats



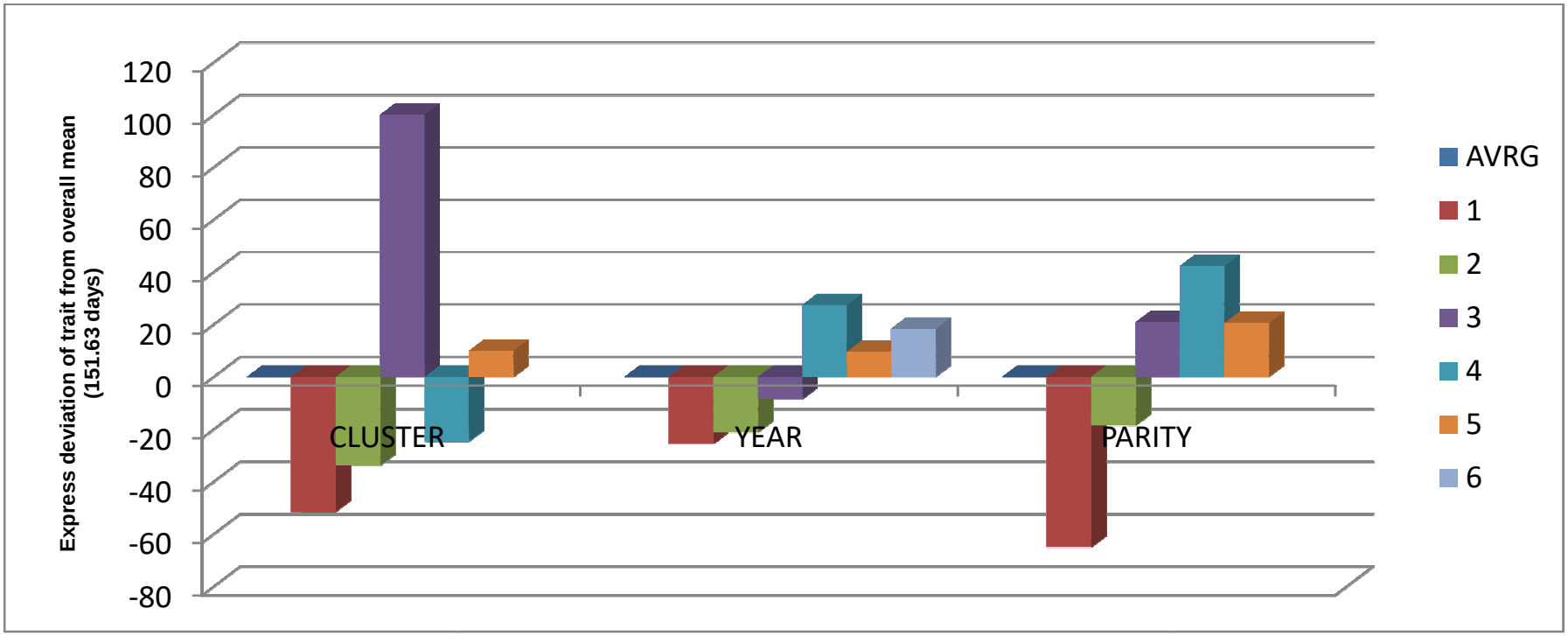
Cluster- 1 to 5 (Vallabhnagar, Railmagra, Devgarh, Nathdwara and Bhadsoda); **Season-** 1 to 3 (Rainy, Winter and Summer); **Year-** 1 to 6 (2007-08, 2008-09, 2009-10, 2010-11, 2011-12 and 2012-13); **Parity-** (1 to 5).

Figure 25. Factors affecting lactation length of Sirohi goats



Cluster- 1 to 5 (Vallabhnagar, Railmagra, Devgarh, Nathdwara and Bhadsoda); **Season-** 1 to 3 (Rainy, Winter and Summer); **Year-** 1 to 6 (2007-08, 2008-09, 2009-10, 2010-11, 2011-12 and 2012-13).

Figure 26. Factors affecting dry period of Sirohi goats



Cluster- 1 to 5 (Vallabhnagar, Railmagra, Devgarh, Nathdwara and Bhadsoda); **Year-** 1 to 6 (2007-08, 2008-09, 2009-10, 2010-11, 2011-12 and 2012-13); **Parity-** (1 to 5).

Sabapara *et al.* (2010), 166.08 ± 1.64 litres in Surti goats by Tyagi *et al.* (2013) were reported. However lower estimates of 49.00±05.642 litres in Sirohi goats and its crosses (Half-bred) with Beetal by Swami *et al.* (2005), 68.09±1.37 litres in Sirohi goats by Gurjar *et al.* (2005), 76.35 ± 1.67 kg in Mehsana goats by Singh *et al.* (2010), 59.42 ± 2.18 litres in Sirohi goats by Pathodiya *et al.* (2010) and 70.23 ± 1.37 litres in Mehsana goats by Patel and Pandey (2013) were observed.

The overall least squares means for lactation length was estimated as 150.75 ± 0.72 days. The lower estimates of 106.93±10.762 days in Sirohi goats by Swami *et al.* (2005), 5.42±0.10 months in Surti goats by Sabapara *et al.* (2010) were recorded. However, higher estimates of lactation length as 167.28 ± 0.82 days in nondescript and graded Sirohi goats by Gokhale *et al.,* (1997), 154.85 ± 1.68 days in in Sirohi goats by Gurjar *et al.* (2005), 202.5±5.65 days in Kutchi goats by Kumar *et al.* (2006), 186.1 ±17.9 days in Sirohi goats by Singh and Ramachandran (2007), 219.05 ± 4.86 days in Mehsana goats by Singh *et al.* (2010), 163.28 ± 3.53 days in Sirohi goats by Pathodiya *et al.* (2010) and 224.00 ± 4.19 days in Mehsana goats by Patel and Pandey (2013) were recorded.

The overall least squares means of dry period was estimated as 151.63 ± 14.25 days. The lower estimates were reported as 149.87 ± 1.16 days in crossbred of local x Sirohi goats by Yadav and Khada (2009), 110.73 ± 8.29 days in Mehsana goats by Singh *et al.* (2010) and 112.31 ± 6.64 days in Mehsana goats by Patel and Pandey (2013). Higher estimates were reported as 162.8 ± 55.1 and 190.8 ± 76.9 days in Malabari and Sannen half-breeds Mukundan *et al.* (1983) and Pathodiya *et al.* (2008) reported as 183.58±13.97 days in Sirohi goats.

4.7.1 Genetic and non-genetic factors affecting production traits

As revealed by ANOVA given in Table 4.13 various effects of genetic and non-genetic factors affecting production traits were presented.

4.7.1.1 Effect of sire

The random effect of sire was highly significant (P≤ 0.01) on average test day milk yield, 90 days milk yield, 150 days milk yield, total milk yield, lactation length and dry period. The result is in agreement with the findings of Pathodiya *et al*. (2008) on dry period and Pathodiya *et al.* (2010) in Sirohi goats.

Sire significantly affected the production traits indicating existence of additive genetic variability among these traits and significant influence of sire might be attributed to relative merits of the sires used.

4.7.1.2 Effect of cluster

Cluster-wise variation in average test day milk yield, 90 days milk yield, 150 days milk yield, total milk yield, lactation length and dry period was highly significant (P≤ 0.01) (Figure 21-26). Similar observations were in accordance with Gokhale *et al.,* (1997) and Tyagi *et al.* (2013) for production traits.

These differences may be attributed to differences in managemental practices between clusters. Significantly highest 90 days milk yield, 150 days milk yield and total milk yield was observed in Devgarh cluster compared with other four clusters and lowest estimates in Vallabhnagar cluster. Railmagra cluster have highest Lactation length followed by Bhadsoda and Devgarh. Total milk production was highest in Devgarh cluster but lactation length was highest in Railmagra cluster, it indicates Devgarh cluster animals performing better than Railmagra cluster. Dry period was least in Vallabhnagar cluster and highest in Devgarh cluster, huge difference was seen in dry period of these two clusters, however Devgarh cluster have almost second position lactation length. The longer dry period indicated failure of does to conceive within 40 days of parturition. Reason for this may be the problem of infertility. Devgarh cluster animals need to provide good managemental practices and balance

nutritional ration which subside the breeding problems like repeat breeding and also need to watch on estrous period, artificial insemination and embryo transfer techniques.

4.7.1.3 Effect of season

Influence of season of birth was highly significant (P≤ 0.01) on average test day milk yield, 150 days milk yield and lactation length, significant (P≤ 0.05) 90 days milk yield and total milk yield (Figure 21-25). This finding is in agreement with Chander *et at.* (1971), Mukundan *et al.* (1983), Misra *et al.* (1983) on lactation yield and lactation length, Gokhale *et al.,* (1997) on lactation yield, Swami *et al.* (2005) on lactation yield, Gurjar *et al.* (2005) and Tyagi *et al.* (2013) on all lactation traits. Non-significant effect of season was reported by Singh and Ramachandran (2007) on all production traits, Pathodiya *et al.* (2008) on dry periods.

The lowest and highest 150 days milk yield and total milk yield were observed in goats kidded during rainy and summer season respectively. The lactation length of goats kidded during winter season was higher than those kidded during summer and rainy season. The total milk yield of goats kidded during summer and winter was 3.50% and 1.82% higher as compared to goats kidded during rainy season. Significantly lower lactation performance of Sirohi goats kidded during rainy season might be attributed to climatic stress of higher humidity and rainfall during rainy season. Non-significant variation was observed in the dry periods of Sirohi goats born during all three seasons. These seasonal differences in lactation performance calls for implementation of mating plans with proven bucks to minimize seasonal differences and fulfilling demand of goat milk throughout the year.

4.7.1.4 Effect of year

Effect due to year of kidding were found to be highly significant (P≤ 0.01) on average test day milk yield, 90 days milk yield, 150 days

milk yield, total milk yield, lactation length and dry period (Figure 21-26). Chander *et at.* (1971), Gokhale *et al.,* (1997), Swami *et al.* (2005), Gurjar *et al.* (2005), Kumar *et al.* (2006), Singh and Ramachandran (2007) and Pathodiya *et al.* (2008) were reported significant effect on dry periods, Pathodiya *et al.* (2010) was reported significant effect on total Lactation milk yield and total lactation length. Tyagi *et al.* (2013) also reported significant effects of year of kidding on these traits.

The 90 days milk yield was increasing from year 2007 to 2013. The 150 days milk yield and total milk yield were observed increasing order from year 2009 to 2013. Highest lactation length was observe in year 2007, then remain constant for three years and goes decrease in last two years. Dry period was increasing pattern up to 2011 and then decreases. The period differences might be due to variability in environmental conditions and differential availability of pastures during these periods.

4.7.1.5 Effect of parity

Parity wise variation in average test day milk yield, 90 days milk yield, 150 days milk yield, total milk yield and dry period was highly significant (P≤ 0.01), whereas lactation length was non-significant (Figure 21-24 and 26). The result is in agreement with the findings of Gokhale *et al.,* (1997), Swami *et al.* (2005), Gurjar *et al.* (2005), Kumar *et al.* (2006), Singh and Ramachandran (2007), Sabapara *et al.* (2010) and Tyagi *et al.* (2013).

Milk yield was lowest for animals kidding for first time. The 90 days milk yield was in increasing order from first parity to fifth and above parity. 150 days milk yield, total milk yield and dry period were increased up to fourth parity but slightly declined in fifth parity. Total milk yield was reached its maximum in the fourth parity. The lactation length did not differ significantly between parities. Increase in milk yield with increase in parity would be due to the growth and development of different body system, especially the udder. The decline in milk yield

after the attainment of maximum milk production would occur due to senile change which set in with ageing and result in a decrease of functionally active tissue of the udder.

4.7.1.5 Effect of type of birth

Type of kidding had significant (P≤ 0.05) effect on 90 days milk yield (Figure 22). Similar results were observed by Gokhale *et al.,* (1997) and Gurjar *et al.* (2005). Non-significant difference was observed by Swami *et al.* (2005) on all lactation traits except daily milk yield. The 90 days milk yield was higher in single born kids than the multiple.

4.7.1.6 Effect of dam's weight at kidding

The regression of dam's weight at kidding had significant (P≤ 0.01) effect on average test day milk yield, 90 days milk yield, 150 days milk yield, total milk yield and dry period, however non-significant on lactation length. These findings were in agreement to the observations of Mukundan *et al.* (1983) on total milk yield and lactation length, Misra *et al.* (1985), Swami *et al.* (2005) except lactation length and Singh and Ramachandran (2007). Pathodiya *et al.* (2010) was reported non-significant effect on production traits. The regression of dam's weight at kidding was significant on all production traits, which indicated that heavier does at kidding had higher 90 days milk yield, 150 days milk yield, total milk yield.

4.7.1.7 Genetic and phenotypic parameters for production traits

The results regarding estimated genetic and phenotypic parameters *viz*. heritability, genetic and phenotypic correlations of a population are presented in Table 4.15.

The heritability estimates for production traits under study were of high magnitude. The heritability estimates for production traits ranged between 0.391 ± 0.087 to 0.652 ± 0.101. Similar results were

also reported by Pathodiya *et al.* (2010). This indicates, sire used in the field have different in genetic potential. Therefore, these traits can be improved through approaching mass selection. The genetic correlation obtained was positive and high except lactation length with 90 and 150 days milk yield was negative correlation. The phenotypic correlation's except lactation length with 90 days milk yield (low and negative) was positive and high among production traits under study. The positive genetic correlation of 90 days milk yield and 150 milk yield with total milk yield indicated selection for higher total milk yield would increase milk yield and simultaneously provides a selection criterion in the early lactation.

Table No. 4.15. Estimates of heritability (on diagonal), genetic correlation (above diagonal) and phenotypic correlation (below diagonal) among milk production trait in Sirohi goats.

Trait	Average Test Day Milk Yield	90 Days Milk Yield	150 Days Milk Yield	Total Milk Yield	Lactation Length	Dry Period
Average Test Day Milk Yield	**0.442 ± 0.100**	0.686 ± 0.042	0.517 ± 0.062	0.577 ± 0.071	-0.463 ± 0.156	0.550 ± 0.027
90 Days Milk Yield	0.584 ± 0.017	**0.652 ± 0.101**	0.684 ± 0.008	0.671 ± 0.011	-0.205 ± 0.151	0.650 ± 0.049
150 Days Milk Yield	0.677 ± 0.040	0.515 ± 0.013	**0.614 ± 0.108**	0.596 ± 0.001	-0.034 ± 0.149	0.594 ± 0.039
Total Milk Yield	0.657 ± 0.032	0.601 ± 0.010	0.696 ± 0.010	**0.594 ± 0.106**	0.048 ± 0.150	0.498 ± 0.038
Lactation Length	-0.116 ± 0.040	-0.042 ± 0.030	0.071 ± 0.027	0.150 ± 0.026	**0.475 ± 0.095**	0.032 ± 0.169
Dry Period	0.542 ± 0.022	0.588 ± 0.017	0.502 ± 0.020	0.602 ± 0.017	0.093 ± 0.026	**0.391 ± 0.087**

Note: Phenotypic correlations are highly significant tested by‘t’ test.

4.8 Reproduction performance and factors affecting it.

The overall least squares means for reproduction traits have been presented in table 4.17.

The overall least squares means for age at first conception was estimated as 523.81 ± 38.93 days. Lower estimates reported as 425 ± 15 days in Malabari goats by Mukundan *et al.* (1983), 512.17 ± 15.33 days in Beetal goats by Singh *et al.* (2002), 209 ± 32.25 days in Black Bengal goats by Hossain *et al.* (2004), 510.50 ± 3.62 days in Assam Local and its reciprocal crosses by Das *et al.* (2004), 386.29 ± 4.78 in Beetal goats by Maroof *et al.* (2007), 465.6 ± 0.48 days in Sangamneri goats by Deokar *et al.* (2007), 216.94 ± 4.36 days in black, 200.12 ± 4.26 days in white, 205.00 ± 4.23 days in brown varieties of Bengal goat by Das *et al.* (2008), 315.62 ± 1.22 days in crossbred of local x Sirohi goats by Yadav and Khada (2009), 456.90 ± 0.14 days in Mehsana goats by Singh *et al.* (2009), 440.92 ± 3.13 days in Ganjam goats by Rao P. K. *et al.* (2009), 271.20 ± 0.49 days in Surti goats by Sabapara *et al.* (2010), 395.4 ± 29.6 days in Jamunapari goats by Hassan *et al.* (2010), 304.87 ± 0.19 days in Mahabubnagar goats by Ekambaram *et al.* (2011) and 513.70 ± 9.01 days in Sirohi goats by Kumar *et al.* (2012). Higher estimates as 646.01 ± 19.08 days in Sirohi goats by Kumar *et al.* (2005), 545.12 ± 1.48 days in Kutchi goats by Kumar *et al.* (2006) and 560.43 ± 20.83 days in Mehsana goats by Patel and Pandey (2013) was also reported.

The overall least squares means for weight at first conception was estimated as 27.54 ± 0.19 kg. Lower estimates were as 23.2 ± 1.2 kg in Malabari and Sannen half-breds by Mukundan *et al.* (1983), 24.6 and 28.4 kg in Marwari and Parbatsari goats by Patel (2005), 26.15±0.36 kg in Sirohi goats by Kumar *et al.* (2005), 20.02 ± 0.74 kg in crossbred of local x Sirohi goats by Yadav and Khada (2009), 19.90 ± 0.37 kg in Ganjam goats by Rao *et al.* (2009), 26.25±0.12 kg in Sirohi goats by Kumar *et al.* (2012) and 26.00 ± 0.50 kg in Mehsana goats by Patel and Pandey (2013). Higher estimates were reported as

28.30±1.10 kg in Kutchi goats by Kumar *et al.* (2006) and 28.35 ± 1.90 kg in Beetal goats by Maroof *et al.* (2007).

The average of age at first kidding was estimated as 672.63 ± 38.95 days. Lower estimates were reported as 557 ± 48 days in Malabari and Sannen half-breds by Mukundan *et al.* (1983), 401.5 ± 32.08 days in Black Bengal goat by Hossain *et al.* (2004), 653.46 ± 4.61 days in Assam Local by Das *et al.* (2004), 561.24± 9.83 days in semi-intensive, and 632.35 ± 7.83 days in extensive management system of Jakhrana goats by Rai and Singh (2005), 522.83 ± 5.19 in Beetal goats by Maroof *et al.* (2007), 465.60 ± 0.48 in Sangamneri goats by Deokar *et al.* (2007), 370.04± 4.45 days in black, 358.17± 5.33 days in white and 360.47 ± 4.47 days brown Bengal goat by Das *et al.* (2008), 421.20 ± 0.56 days in Surti goat by Deshpande *et al.* (2009), 436.52 ± 4.34 days in crossbred of local x Sirohi goats by Yadav and Khada (2009), 609.60 ± 0.13 days in Mehsana goats by Singh *et al.* (2009), 618.88 ± 2.14 days in Ganjam goats by Rao *et al.* (2009), 428.40 ± 0.38 days in Surti goats by Sabapara *et al.* (2010), 548.6 ± 68.1 days in Jamunapari goats by Hassan *et al.* (2010) and 455.65 ± 0.19 days in Mahabubnagar goats by Ekambaram *et al.* (2011). Higher estimates of 686.50 ± 16.26 days in Beetal, Black Bengal and their reciprocal crosses by Singh *et al.* (2002), 794.95±19.03 days in Sirohi goats by Kumar *et al.* (2005), 698.41±1.49 days in Kutchi goats by Kumar *et al.* (2006), 747.38±20.82 days in Sirohi goats by Kumar *et al.* (2012) and 716.52 ± 19.01 days in Mehsana goats by Patel and Pandey (2013) were reported.

The average of weight at first kidding was 31.10 ± 0.41 kg. Lower estimates were observed as 23.2 ± 1.2 kg in Malabari and Sannen half-breds by Mukundan *et al.* (1983), 15.41 ± 1.35 kg in Black Bengal goat by Hossain *et al.* (2004), 29.66±0.41 kg in Sirohi goats by Kumar *et al.* (2005), 23.87 ± 0.67 kg in crossbred of local x Sirohi goats by Yadav and Khada (2009), 22.97 ± 0.36 kg in Ganjam goats by Rao *et al.* (2009) and 28.63±0.12 kg in Sirohi goats by Kumar *et al.* (2012).

Table 4.16 Least squares analysis of variance for various factors affecting reproduction traits in Sirohi goats

SOURCE	Age at first conception		Weight at first conception		Age at first kidding		Weight at first kidding		Gestation Period		Kidding Interval	
	D.F.	M.S.	D.F.	M.S.	D.F.	M.S.	D.F.	M.S.	D.F.	M.S.	D.F.	M.S.
Sire	65	35543.83 **	89	546.80*	89	540.96**	89	44.31**	89	17576.97**	65	2807.48
Cluster	3	24918.63 *	4	14147.53**	4	14333.10*	4	90.97**	4	25289.16**	3	1240.46
Year of kidding	5	1320471.25 **	2	765.15**	2	660.38**	2	202.97**	2	9701.99**	5	3355.58
Season of kidding	2	140231.57 **	5	707.04	5	599.40**	5	176.94	5	41020.19**	2	111591.22**
Year of birth	8	554103.11 **	4	12250.94**	4	12601.77**	4	28.97**	4	23430.97	8	2390.78
Season of birth	2	22468.36	1	102.81	1	76.03	1	18.02*	1	6095.67	2	27367.67**
Reg. on DWK	1	172935.33 **	1	118.35**	1	103.98**	1	37.35	1	1762.63	1	719.50
Error	411	15106.575953	411	1.079408	411	15122.286333	411	2.897528	411	1.694198	411	5421.513153

Note: D.F. =Degree of freedom, Reg. on DWK = Regression on weight of dam at kidding. ** = Highly significant (P≤0.01), *= Significant (P≤0.05).

Table No 4.17. Least-squares means and S.E. for reproduction traits of Sirohi goat

Traits / Factors	Age at first conception (Days)	Weight at first conception (Kg)	Age at first kidding (Days)	Weight at first kidding (Kg)	Gestation Period (Days)	Kidding Interval (Days)
Overall mean (μ)	523.81± 38.93 (499)	27.54 ± 0.19 (499)	672.63 ± 38.95 (499)	31.10 ± 0.41 (499)	148.82 ± 0.31 (499)	290.61± 11.38 (499)
Sire	**	*	**	**	**	NS
Cluster	*	**	*	**	**	NS
Vallabhnagar	607.80 ± 65.67^{b} (23)	29.85 ± 0.82^{c} (23)	757.86 ± 65.69^{b} (23)	32.07 ± 0.82^{b} (23)	149.95 ± 0.62^{bc} (23)	E ± 32.97 (23)
Railmagra	500.35 ± 55.56^{a} (105)	25.79 ± 0.67^{a} (105)	650.86 ± 56.10^{a} (105)	29.50 ± 0.68^{a} (105)	150.51 ± 0.51^{c} (105)	299.72 ± 26.04 (105)
Devgarh	487.55 ± 52.96^{a} (350)	27.27 ± 0.62^{b} (350)	637.38 ± 53.50^{a} (350)	29.72 ± 0.64^{a} (350)	149.83 ± 0.48^{b} (350)	293.39 ± 24.05 (350)
Bhadsoda	540.55 ± 109.01^{ab} (21)	30.07 ± 1.47^{c} (21)	685.23 ± 109.06^{a} (21)	33.12 ± 1.45^{c} (21)	144.68 ± 1.10^{a} (21)	277.76 ± 61.13 (21)
Year of kidding	**	**	**	**	**	NS
2007	500.52 ± 49.92^{b} (103)	25.55 ± 0.57^{a} (103)	648.61 ± 50.02^{b} (103)	28.99 ± 0.59^{a} (103)	148.09 ± 0.44^{a} (103)	275.83 ± 21.27 (103)
2008	365.28 ± 45.92^{a} (67)	26.67 ± 0.49^{b} (67)	513.49 ± 45.94^{a} (67)	29.38 ± 0.52^{a} (67)	148.26 ± 0.38^{a} (67)	265.85 ± 17.76 (67)
2009	359.95 ± 43.73^{a} (111)	28.72 ± 0.45^{c} (111)	508.67 ± 43.75^{a} (111)	30.78 ± 0.48^{b} (111)	148.72 ± 0.36^{b} (111)	287.51 ± 15.71 (111)
2010	648.45 ± 44.26^{c} (79)	29.29 ± 0.46^{d} (79)	797.75 ± 44.28^{c} (79)	31.22 ± 0.49^{b} (79)	148.30 ± 0.36^{a} (79)	300.11 ± 16.23 (79)
2011	645.29 ± 46.53^{c} (72)	29.31 ± 0.50^{d} (72)	794.24 ± 46.55^{c} (72)	32.34 ± 0.53^{c} (72)	148.95 ± 0.39^{b} (72)	289.83 ± 18.32 (72)
2012	618.32 ± 49.66^{c} (67)	29.93 ± 0.56^{e} (67)	768.60 ± 49.68^{c} (67)	33.90 ± 0.58^{d} (67)	150.14 ± 0.43^{bc} (67)	298.00 ± 20.99 (67)

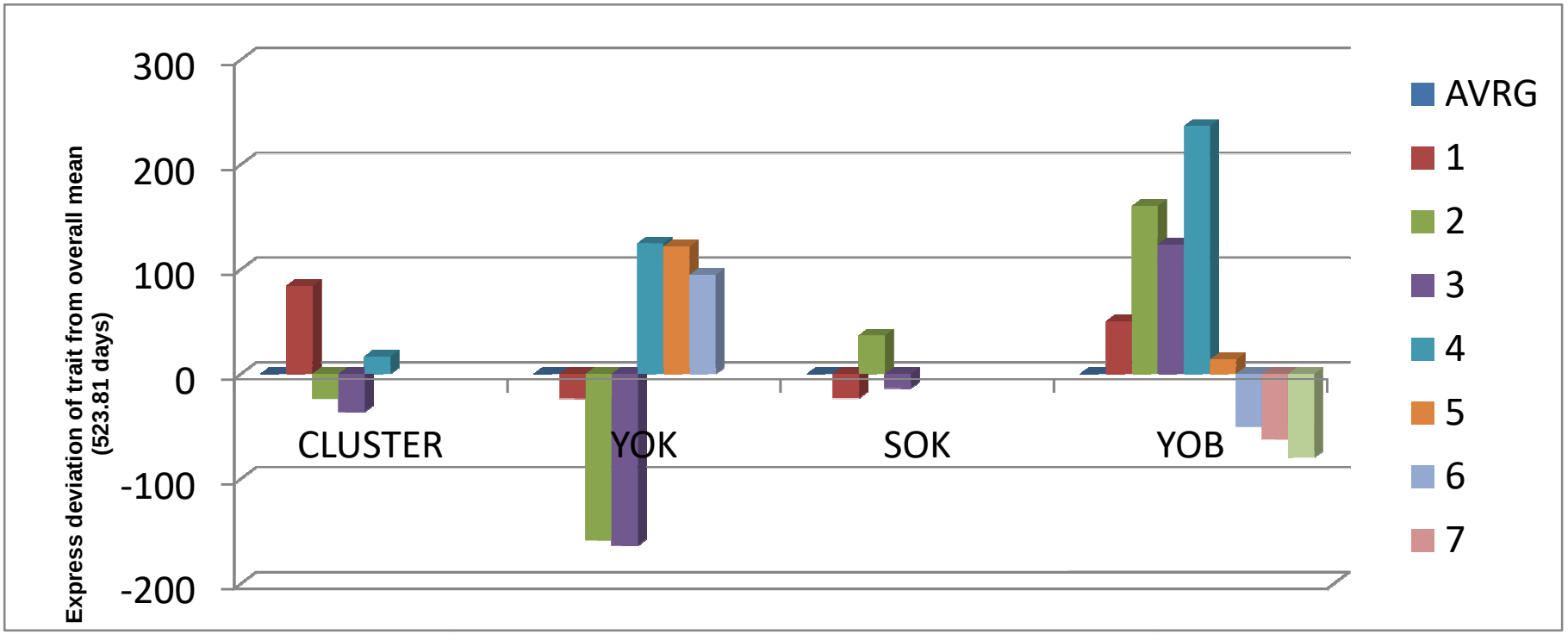
Season of kidding	**	NS	**	NS	**	**
Rainy	500.61 ± 40.49[a] (162)	28.30 ± 0.39 (162)	649.89 ± 40.51[a] (162)	31.12 ± 0.43 (162)	149.19 ± 0.31[c] (162)	191.91 ± 12.30[a] (162)
Winter	560.60 ± 39.69[b] (243)	28.39 ± 0.37 (243)	709.40 ± 39.71[b] (243)	31.32 ± 0.41 (243)	148.71 ± 0.30[b] (243)	255.58 ± 11.35[b] (243)
Summer	510.19 ± 41.13[a] (94)	28.04 ± 0.40 (94)	658.60 ± 41.15[a] (94)	30.86 ± 0.44 (94)	148.33 ± 0.32[a] (94)	411.08 ± 13.03[c] (94)
Year of birth	**	**	**	**	NS	NS
2004	574.07 ± 59.01[c] (30)	30.66 ± 0.71[e] (30)	723.06 ± 59.04[d] (30)	33.06 ± 0.73[e] (30)	149.86 ± 0.54 (30)	242.84 ± 28.22 (30)
2005	684.06 ± 57.72[de] (52)	30.37 ± 0.69[e] (52)	833.10 ± 57.74[ef] (52)	33.02 ± 0.71[e] (52)	149.04 ± 0.53 (52)	256.86 ± 27.27 (52)
2006	647.36 ± 47.41[d] (83)	29.68 ± 0.52[d] (83)	796.49 ± 47.43[e] (83)	32.75 ± 0.54[e] (83)	149.13 ± 0.40 (83)	287.11 ± 19.09 (83)
2007	760.42 ± 43.35[e] (112)	29.01 ± 0.45[c] (112)	909.67 ± 43.37[f] (112)	32.22 ± 0.48[d] (112)	149.25 ± 0.35 (112)	294.68 ± 15.34 (112)
2008	537.71 ± 42.51[c] (79)	28.02 ± 0.43[b] (79)	687.16 ± 42.53[d] (79)	30.90 ± 0.46[c] (79)	149.45 ± 0.34 (79)	295.71 ± 14.49 (79)
2009	473.37 ± 42.78[b] (74)	27.58 ± 0.44[b] (74)	622.56 ± 42.80[c] (74)	30.45 ± 0.47[c] (74)	149.13 ± 0.34 (74)	299.90 ± 14.77 (74)
2010	461.38 ± 48.51[b] (46)	27.52 ± 0.54[b] (46)	609.74 ± 48.53[bc] (46)	29.74 ± 0.56[b] (46)	148.36 ± 0.42 (46)	291.32 ± 20.03 (46)
2011	444.07 ± 57.82[b] (23)	25.30 ± 0.70[a] (23)	592.21 ± 57.84[bc] (23)	27.59 ± 0.71[a] (23)	148.14 ± 0.53 (23)	302.30 ± 27.34 (23)
Season of birth	NS	NS	NS	*	NS	**
Rainy	539.26 ± 39.98 (153)	28.54 ± 0.38 (153)	688.10 ± 40.00 (153)	31.47 ± 0.42[b] (153)	148.75 ± 0.30 (153)	268.24 ± 11.71[a] (153)
Winter	512.98 ± 40.24 (299)	28.03 ± 0.39 (299)	661.80 ± 40.26 (299)	30.87 ± 0.42[a] (299)	148.74 ± 0.31 (299)	294.07 ± 12.02[b] (299)
Summer	519.18 ± 40.89	28.16 ± 0.40	667.99 ± 40.91	30.97 ± 0.44[a]	148.74 ± 74	296.26 ± 12.76[b]

	(117)	(117)	(117)	(117)	(117)	(117)
Regression on weight of dam at kidding	**	**	**	----	NS	NS
Regression coefficient (b) (kg/kg)	09.04± 1.56	0.82 ± 0.03	12.02 ± 3.56	----	0.029 ± 0.037	0.78 ± 2.13

NOTE: No. of observations are given in parentheses. Estimates with different superscripts differ significantly.

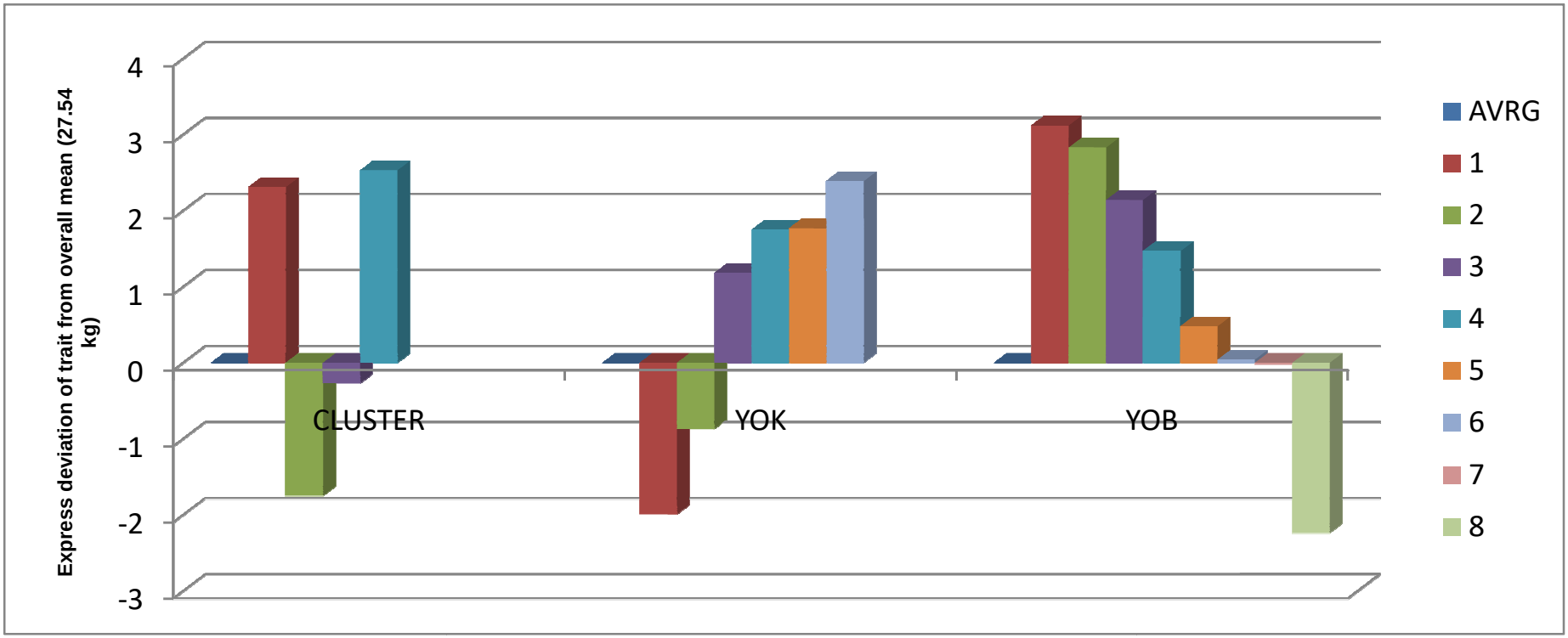
** = Highly significant (P≤0.01), * = Significant (P≤0.05), NS = Non-significant

Figure 27. Factors affecting age at first conception of Sirohi goats



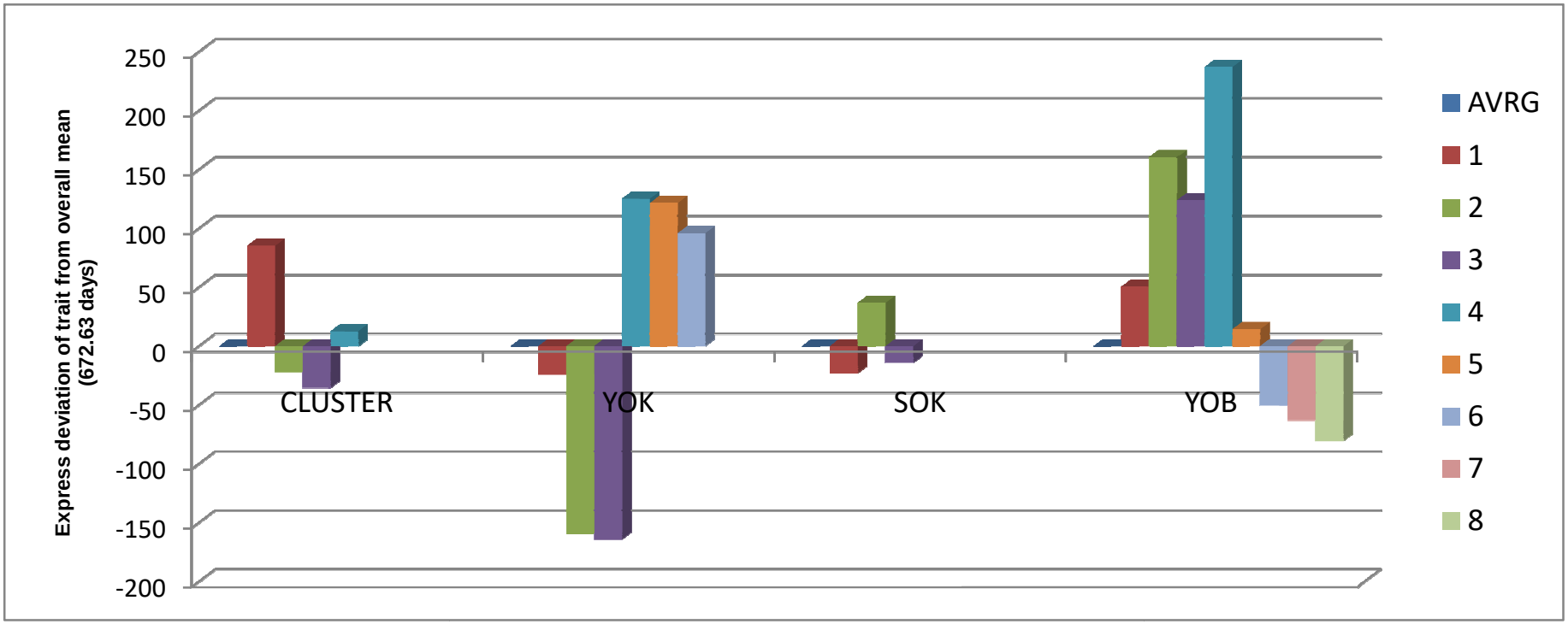
Cluster- 1 to 5 (Vallabhnagar, Railmagra, Devgarh, Nathdwara and Bhadsoda); **Year of kidding-** 1 to 6 (2007-08, 2008-09, 2009-10, 2010-11, 2011-12 and 2012-13), **Season of kidding-** 1 to 3 (Rainy, Winter and Summer); **Year of birth-** 1 to 8 (2004-05, 2005-06, 2006-07, 2007-08, 2008-09, 2009-10, 2010-11 and 2011-12).

Figure 28. Factors affecting weight at first conception of Sirohi goats



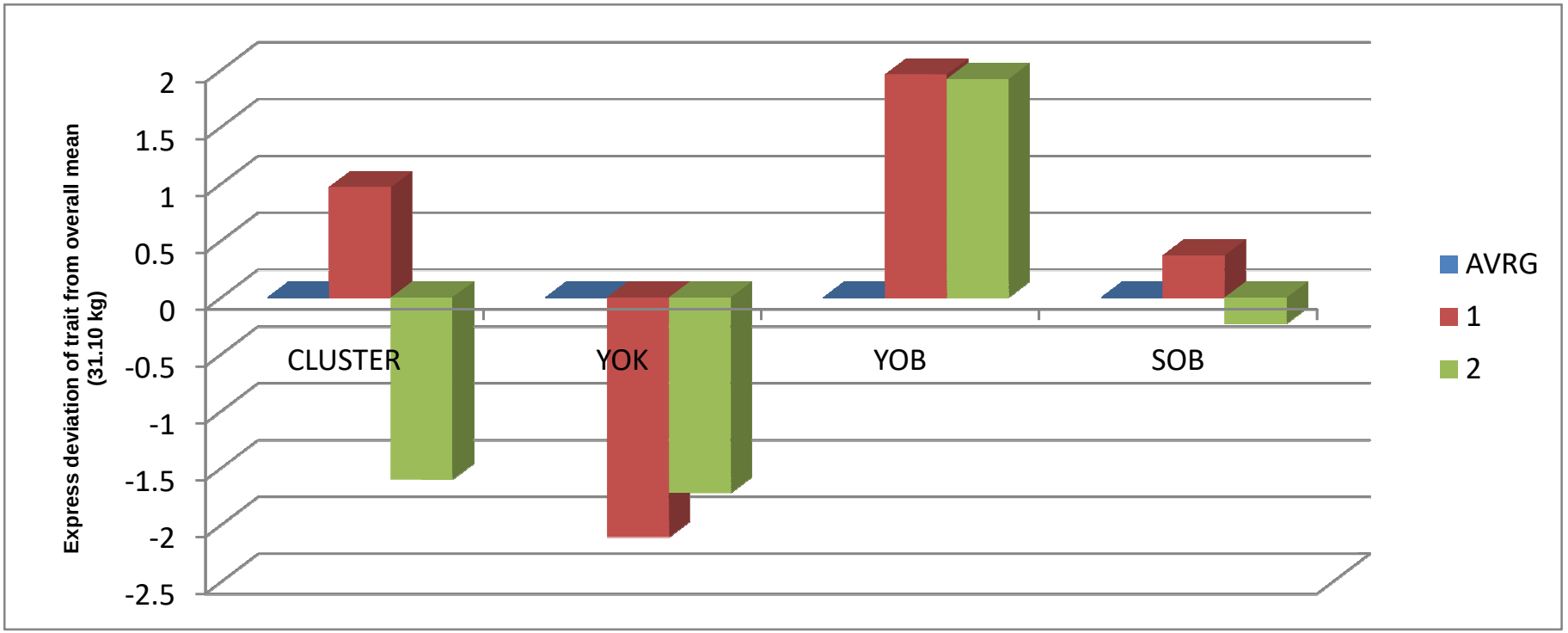
Cluster- 1 to 5 (Vallabhnagar, Railmagra, Devgarh, Nathdwara and Bhadsoda); **Year of kidding-** 1 to 6 (2007-08, 2008-09, 2009-10, 2010-11, 2011-12 and 2012-13), **Year of birth-** 1 to 8 (2004-05, 2005-06, 2006-07, 2007-08, 2008-09, 2009-10, 2010-11 and 2011-12).

Figure 29. Factors affecting age at first kidding of Sirohi goats



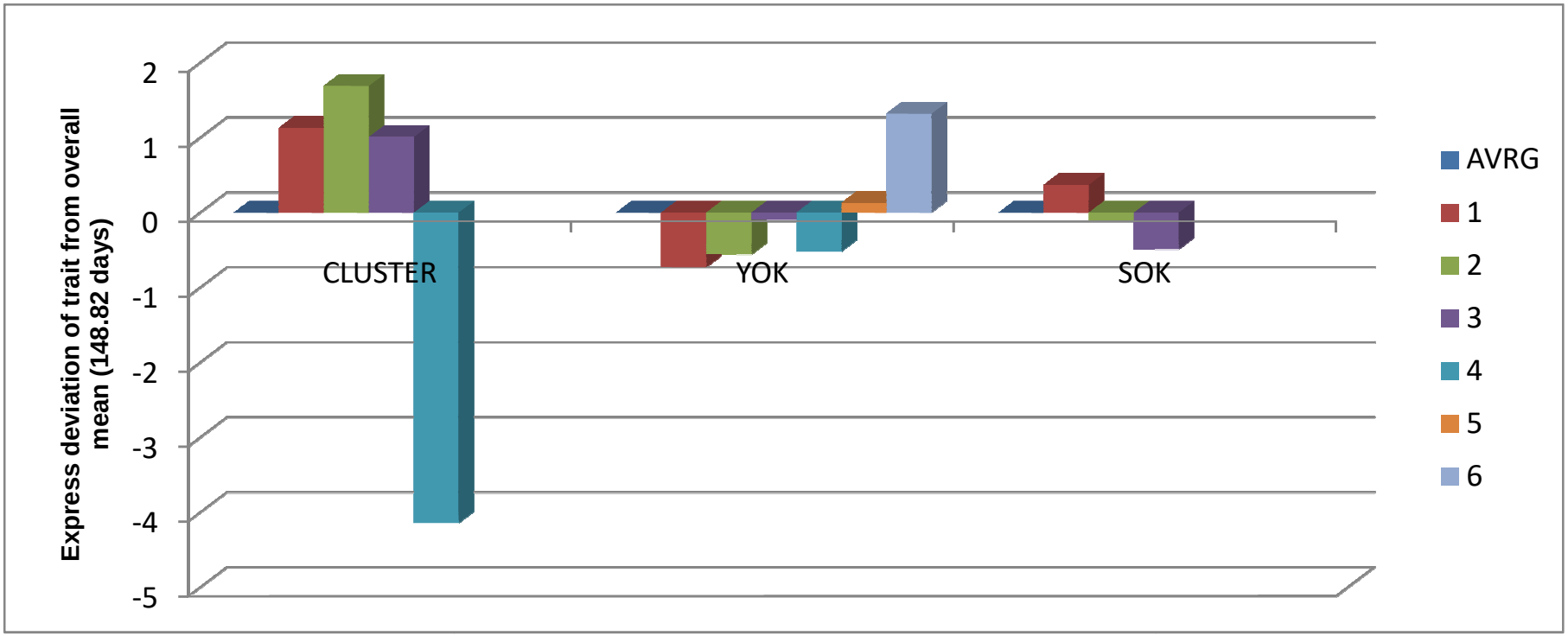
Cluster- 1 to 5 (Vallabhnagar, Railmagra, Devgarh, Nathdwara and Bhadsoda); **Year of kidding-** 1 to 6 (2007-08, 2008-09, 2009-10, 2010-11, 2011-12 and 2012-13), **Season of kidding-** 1 to 3 (Rainy, Winter and Summer); **Year of birth-** 1 to 8 (2004-05, 2005-06, 2006-07, 2007-08, 2008-09, 2009-10, 2010-11 and 2011-12).

Figure 30. Factors affecting weight at first kidding of Sirohi goats



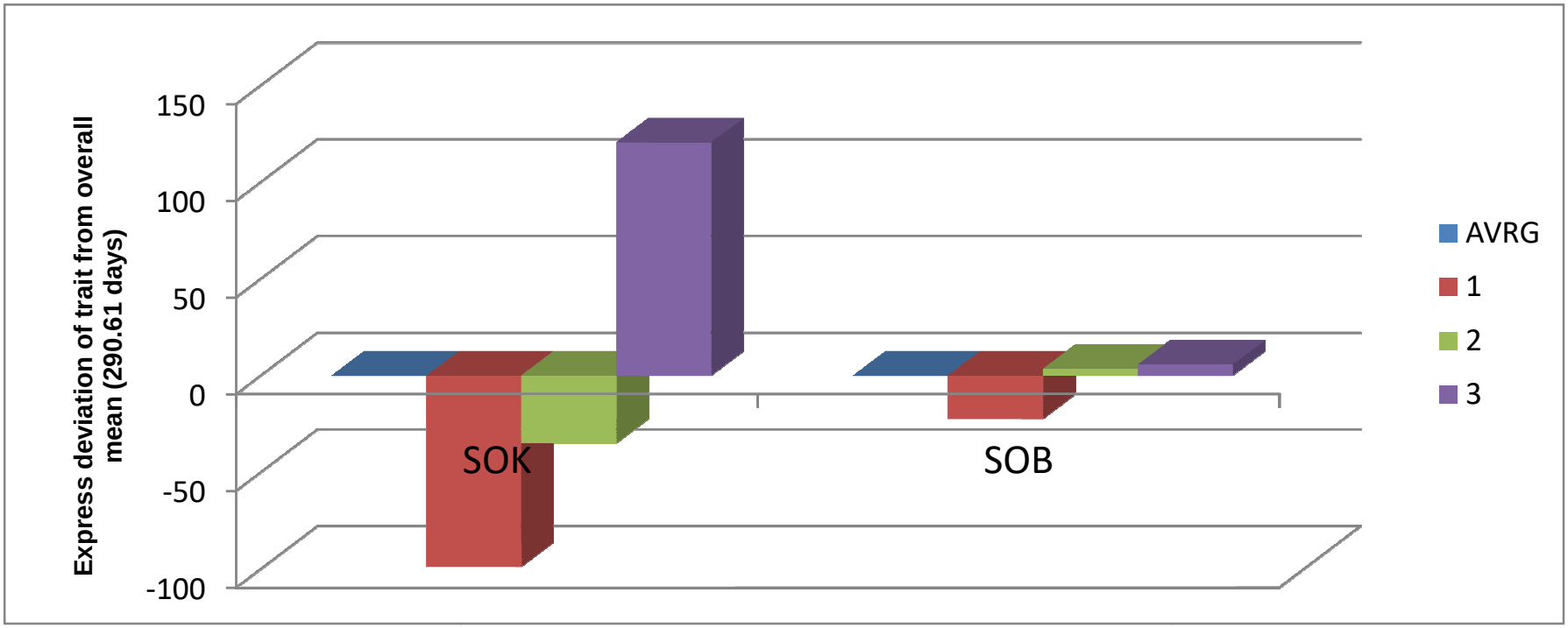
Cluster- 1 to 5 (Vallabhnagar, Railmagra, Devgarh, Nathdwara and Bhadsoda); **Year of kidding-** 1 to 6 (2007-08, 2008-09, 2009-10, 2010-11, 2011-12 and 2012-13),; **Year of birth-** 1 to 8 (2004-05, 2005-06, 2006-07, 2007-08, 2008-09, 2009-10, 2010-11 and 2011-12); **Season of birth-** 1 to 3 (Rainy, Winter and Summer)

Figure 31. Factors affecting gestation period of Sirohi goats



Cluster- 1 to 5 (Vallabhnagar, Railmagra, Devgarh, Nathdwara and Bhadsoda); **Year of kidding-** 1 to 6 (2007-08, 2008-09, 2009-10, 2010-11, 2011-12 and 2012-13),; **Season of kidding-** 1 to 3 (Rainy, Winter and Summer).

Figure 32. Factors affecting kidding interval of Sirohi goats



Season of kidding- 1 to 3 (Rainy, Winter and Summer); **Season of birth-** 1 to 3 (Rainy, Winter and Summer).

Higher estimates of 32.88±4.12 kg in Kutchi goats were reported by Kumar *et al.* (2006) and 31.58 ± 0.29 kg in Mehsana goats by Patel and Pandey (2013).

The overall least-squares means of gestation period was estimated as 148.82 ± 0.31 days. Similar observations were recorded as 148.26±1.43 days in Sangamneri goats by Deokar *et al.* (2007) and 148.97 ± 0.28 days in Mehsana goats by Patel and Pandey (2013). The lower estimates were reported as 146.41 ± 0.24 days in Sirohi does by Mishra *et al.* (1979), 142.6 ± 0.5 days in Black Bengal, ½ Black Bengal + ½ Jamunapari, ½ Black Bengal + Beetal goats, 147.4 ± 1.2 days in Malabari and Sannen half-breds by Mukundan *et al.* (1983), 145.01 ± 0.06 in Assam Local by Das *et al.* (2004), 145.22±0.46 days in Kutchi goats by Kumar *et al.* (2006), 144.08±1.01 days in Black Bengal goats by Roy *et al.* (2007), 145.39± 0.06 days of black 144.34± 0.79 days of white and 147.02± 0.59 of brown Bengal goats by Das *et al.* (2008), 147.20±0.41 days in Surti goats by Sabapara *et al.* (2010) 145.745 ± 0.302 days in Assam Local by Rumi *et al.* (2011) and 144.71 days in Black Bengal goats by Mia *et al.* (2013). However, higher estimates of 149.04 ± 2.04 days in Beetal goats by Maroof *et al.* (2007), 150.12±0.40 days in Sirohi goats by Pathodiya *et al.* (2008), 150.34 ± 0.87 day in crossbred of local x Sirohi goats by Yadav and Khada (2009), 149.23 ± 2.11 days in Ganjam goats by Rao *et al.* (2009) and 152.8 ± 17.6 days in Jamunapari goats by Hassan *et al.* (2010) were recorded.

The overall least-squares means for kidding interval was estimated as 290.61± 11.38 days. Higher estimates of kidding interval were reported by Mukundan *et al.* (1983) as 338 ± 41 days in Malabari and Sannen half-breds, Das *et al.* (2004) as 300.92 ± 0.89 days in Assam Local, Rai and Singh (2005) as 287.78 ± 9.89 days in Jakhrana goats, Kumar *et al.* (2006) as 411.17 ± 50.95 days in Kutchi goats, Maroof *et al.* (2007) as 350.50 ± 6.08 days in Beetal goats, Pathodiya *et al.* (2008) as 341.53 ±13.16 days in Sirohi goats, Yadav and Khada

(2009) as 308.66 ± 0.79 days in crossbred of local x Sirohi goats, Rao *et al.* (2009) as 304.15 ± 3.17 days in Ganjam goats, Singh *et al.* (2009) as 322.27 ± 1.77 days in Mehsana goats and Patel and Pandey (2013) as 364.40 ± 4.32 days in Mehsana goats. However, Lower estimates of kidding interval were reported by Deokar *et al.* (2007) as 218.48±10.44 days in Sangamneri goats, Das *et al.* (2008) reported as 229.05± 3.79 days in black, 221.45 ± 5.31 days in white and 228.93 ± 5.32 days in brown Bengal goats, , 234.00 ± 0.20 days in Surti goats and Ekambaram *et al.* (2011) reported as 254.92 ± 0.25 days in Mahabubnagar goats.

4.8.1 Genetic and non-genetic factors affecting reproduction traits

4.8.1.1 Effect of sire

Random effect of sire was highly significant (P≤ 0.01) on all traits under this study except kidding interval, which was non-significant. Mishra *et al.* (1979) also observed non-significant effect of sire Table 4.16. Pathodiya *et al*. (2008) reported significant effect of sire on kidding interval and Hossain *et al.* (2004) reported significant of sire on gestation period.

4.8.1.2 Effect of cluster

Cluster-wise variation was highly significant (P≤ 0.01) on weight at first conception, weight at first kidding and gestation period, significant (P≤ 0.05) on age at first conception and age at first kidding, while kidding interval was not influenced by cluster (Figure 27-31). Pathodiya *et al.* (2008) reported non–significant effect of cluster on kidding interval. Singh *et al.* (2009) reported significant effect on age at first conception. Ekambaram *et al.* (2011) reported significant effect on age at first conception, age at first kidding and kidding interval.

Age at first conception and age at first kidding were lowest in Devgarh cluster and highest in Vallabhnagar cluster. It indicates that animals in Devgarh cluster get early sexual maturity than Vallabhnagar

clusters. Weight at first conception and weight at first kidding were highest in Bhadsoda cluster. Perusal of data indicates large variation amongst clusters which is obvious due to variation in feeding, housing and health care.

4.8.1.3 Effect of year of kidding

Effect of year of kidding was highly significant (P≤ 0.01) on all traits under this study except kidding interval, which was non-significant (Figure 27-31). Mishra *et al.* (1979) observed non-significant effect of year of kidding on kidding interval, Mukundan *et al.* (1983) for age at first kidding, Singh *et al.* (2002) for age at first conception and kidding interval, Kumar *et al.* (2005) on age at first service, weight at service, age at first kidding and weight at first kidding, Pathodiya *et al.* (2008) on kidding interval, Rumi *et al.* (2011) on age of first conception, age of first kidding, gestation period and kidding interval.

Age at first conception and age at first kidding were lowest in year 2009 and highest in 2010. However weight at first conception and kidding was highest in year 2012 and almost lowest in year 2007. It indicates that even if year 2009 shows early maturity in animals but weight was highest in year 2012. Gestation period was also highest in year 2012, which might be due to the differences in plane of nutrition, availability of top feeds, cropping pattern and climatic conditions.

4.8.1.4 Effect of season of kidding

Influence of season of birth highly significant (P≤ 0.01) on age at first conception, age at first kidding, gestation period and kidding interval, while weight at first conception, weight at first kidding was non-significant (Figure 27, 29, 31 and 32). Mukundan *et al.* (1983) on weight at service and weight at kidding, Pathodiya *et al.* (2008) reported significant effect on kidding interval.

Rainy season kidding had lowest age of first conception and age of first kidding and kidding interval, whereas highest in winter season.

Summer season had highest kidding interval and lowest gestation periods. The seasonal variation seems to be results of photometry as their breeding seasons are restricted to February-April and September-November because these are peak breeding seasons.

4.8.1.5 Effect of year of birth

Effect of year of birth was highly significant (P≤ 0.01) on age at first conception, weight at first conception, age at first kidding and weight at first kidding (Figure 27-30). Similar finding were observed by Singh *et al.* (2002) on age of first conception and age at first kidding. Mukundan *et al.* (1983) reported significant on age at first kidding.

Pattern of age of first conception and kidding was in decreasing order from year 2007 to 2012 and highest was observed in year 2007. However weight at first conception and kidding was also declined up to year 2011 and increased in year 2012.

4.8.1.6 Effect of season of birth

Influence of season of birth was highly significant (P≤ 0.01) on kidding interval and significant (P≤ 0.05) on weight at first kidding, while other traits were non-significant (Figure 30 and 32). Season of birth was non-significant was reported by Das *et al.* (2004) on age at first conception and age of first kidding, Rumi *et al.* (2011) on age at first conception.

Rainy season kidded animal have highest kidding weight and lowest kidding interval.

4.8.1.7 Effect of regression of dam's weight at kidding

Regression of dam's weight at kidding was observed positive in the present study. Similar observations were reported as follows. Mishra *et al.* (1979) observed non-significant effect of dam's weight with gestation period. Kumar *et al.* (2011) reported birth weight of does had significant effect on age of first conception and age of first kidding,

indicates that individual weighing heavier at birth attain sexual maturity earlier than those with lower weight at birth.

4.8.1.8 Genetic and phenotypic parameters for reproduction traits

The results regarding estimated genetic and phenotypic parameters *viz*. heritability, genetic and phenotypic correlations are presented in Table 4.18.

The heritability estimates for reproduction traits under study were of high magnitude. The heritability estimates for reproduction traits ranged between 0.104 ± 0.124 to 0.502 ± 0.178 for weight at first conception and age at first conception. Similar observation was recorded by Das *et al.* (2004). High estimates of heritability obtained in the present study indicated the scope of reducing the age at first conception, age at first kidding, gestation period and kidding interval through selection in these herds of goats. The phenotypic and genetic correlations among age at first conception, age first kidding and kidding interval were positive and medium in magnitude.

Table No. 4.18. Estimates of heritability (on diagonal), genetic correlation (above diagonal) and phenotypic correlation (below diagonal) among reproduction traits in Sirohi goats.

Trait	Age at first conception	Weight at first conception	Age at first kidding	Gestation Period	Kidding Interval
Age at first conception	**0.502 ± 0.178**	-0.115 ± 0.439	0.590 ± 0.249	0.049 ± 0.276	0.302 ± 0.223
Weight at first conception	0.072 0.044	**0.104 ± 0.124**	0.117 ± 0.439	-0.228 ± 0.568	0.274 ± 0.341
Age at first kidding	0.501 ± 0.033	0.072 ± 0.043	**0.501 ± 0.178**	0.055 ± 0.276	0.269 ± 0.302
Gestation Period	0.044 ± 0.043	0.020 ± 0.044	0.054 ± 0.044	**0.331 ± 0.147**	0.401 ± 0.197
Kidding Interval	0.003 ± 0.044	-0.029 ± 0.043	0.003 ± 0.042	-0.021 ± 0.043	**0.235 ± 0.124**

Note: Phenotypic correlations are highly significant tested by 't' test

4.8.1.9 Twinning percentage and sex ratio

Knowledge of sex ratio in breeding population helps in maximizing genetic gain by enhancing the intensity of selection. It is generally established that the sex ratio do not deviate significantly from 50 %. Still there are some factors, which might influence on the deviation of the sex ratio.

The year wise, cluster wise and season wise male and female births and sex ratio are presented in Table 4.19, 4.20 and 4.21. The overall single, twins and triplets births in Sirohi goats were 58.74 %, 38.81 % and 2.45 %, respectively as observed under field conditions. Higher estimates of twinning per cent were observed 59.03 % in Kanni goats by Soundrarajan and Sivakumar (2006), 77.76 % in Beetal goats by Maroof *et al.* (2007), 55.56 % in Black Bengal goats by Roy *et al.* (2007), 44.44 % in Beetal goats by Poonia *et al.* (2009), 58.20 % in Jamunapari goats by Hassan *et al.* (2010), 50.89 % in Surti goat by Sabapara et al. (2010), 48.78 % in Sikkim Local goats by Chandra *et al.* (2011) and 51.45 % in Mahabubnagar goats by Ekambaram *et al.* (2011).

Out of 3551 total births recorded, 1768 and 1783 i.e. 49.79:50.21 per cent were males and females, respectively. Higher estimates of male to female ratio were 57 : 43 per cent recorded by Hossain *et al.* (2004) in Black Bengal goat, 57.71: 42.29 per cent by Soundrarajan and Sivakumar (2006) in Kanni goats, 50.35 : 49.65 per cent by Poonia *et al.* (2009) in Beetal goats, 53.3 : 46.7 per cent by Hassan *et al.* (2010) in Jamunapari goats, 52.14 : 47.86 per cent by Chandra *et al.* (2011) in Sikkim Local goats. The results revealed that the differences between the years were non-significant. Highest twinning per cent was observed to be 42.09 % in 2012 while it was lowest 34.62 % in 2007. Sex ratio was higher in 2007 (1: 1.13) and lower in 2011 (1: 0.97) similar result was recorded by Deshpande *et al.* (2009) in Surti goats.

Influence of season was found to be non-significant. Out of 3551 Sirohi kids, 48.52 % were born during winter followed by 36.69 % in rainy season, 14.79 % in winter season. The percentage of male was higher in summer season 51.69 %, sex ratio observed was (1 : 0.93), rainy and winter season have equal sex ratio (1: 1.02). Twinning per cent was highest in rainy season 43.90 % and lowest in winter 33.89 %. This was in agreement with finding reported by Poonia *et al.* (2009) in Beetal goats.

Table No. 4.19. Twinning per cent and sex ratio observed at different clusters.

Cluster	Total births	Type of birth				Sex		
		Single	Twins	Triplet	Twinning per cent	Male	Female	Sex ratio
Vallabhnagar	278	149	120	9	43.16%	146	132	1 : 0.90
Railmagra	650	308	327	15	50.31%	320	330	1 : 1.03
Devgarh	1584	1163	388	33	24.68%	788	796	1 : 1.01
Nathdwara	37	24	10	3	27.03%	18	19	1 : 1.05
Bhadsoda	1002	442	533	27	53.19%	496	506	1 : 1.02
Ovearall	3551	2086 (58.74%)	1378 (38.81%)	87 (2.45%)	38.81%	1768 (49.79%)	1783 (50.21%)	1 : 1.008

Calculated χ^2 = 1.2194E-55^{NS}, 0.915388^{NS} for type of birth and sex, respectively.

Table No. 4.20.Twinning per cent and sex ratio observed at different seasons.

Season	Total births	Per cent birth	Type of birth				Sex		
			Single	Twins	Triplet	Twinning per cent	Male	Female	Sex ratio
Rainy	1303	36.69 %	698	572	33	43.90%	643	660	1 : 1.02
Winter	1723	48.52 %	1097	584	42	33.89%	854	869	1 : 1.02
Summer	525	14.79 %	291	222	12	42.29%	271	254	1 : 0.93

Calculated χ^2 = 4.25048E-07^{NS}, 0.657208^{NS} for type of birth and sex, respectively.

Table No. 4.21. Twinning per cent and sex ratio observed at different periods.

Period	Total births	Type of birth				Sex		
		Single	Twins	Triplet	Twinning per cent	Male	Female	Sex ratio
2007-08	491	315	170	6	34.62%	230	260	1 : 1.13
2008-09	586	325	246	15	41.98%	320	266	1 : 0.83
2009-10	624	365	238	21	38.14%	298	326	1 : 1.09
2010-2011	531	339	186	6	35.03%	272	259	1 : 0.95
2011-2012	668	380	264	24	39.52%	338	330	1 : 0.97
2012-2013	651	362	274	15	42.09%	310	341	1 : 1.10

Calculated $\chi^2 = 0.002095^{NS}$, 0.077951^{NS} for type of birth and sex, respectively.

Cluster was found to be non-significant effect on type of birth and sex ratio. Maximum twinning per cent was observed under Bhadsoda cluster 53.19 %, followed by Railmagra 50.31%, Vallbhnagar 43.16%, Nathdwara 27.03% and Devgarh 24.68%. The percentage of male was higher in Vallbhnagar 52.51 %, sex ratio was observed (1:0.90).

4.9 Prediction equation of body weight from body measurements.

Overall least-squares means ± S.E. of body weight and body measurements of different age group of Sirohi goats are given in table 4.1, 4.2, 4.3 and 4.4. Among the different body measurements, the body height and body girth were highest followed by body length, this trend was noticed till 12 months of age. Study was in agreement with Raja *et al.* (2013) in Attappady Black goats.

The phenotypic correlations of body measurements with body weight were positive, and highly significant (P≤ 0.01). Among the three body measurements body height had maximum correlation with body weight followed by body girth and body length (Table 4.22).

Thiruvenkadan (2005) in Kanni Adu kids, Moaeen-ud-Din *et al.* (2006) in Beetal, Teddi and Crossbred goats, Faizur *et al*. (2007) in Black Bengal Goats, Alex *et al*. (2010) in Malabari goats, Raja *et al.* (2013) in Attappady Black goats, Ruhil *et al.* (2013) in Attappady Black goats, Tyagi *et al*. (2013) in Surti goat, also reported the highest and significant correlation value. Since there is high correlation coefficients between body weight and body measurements, either of these variables or combination could provide a good estimate for predicting live weight in Sirohi goats.

Table No. 4.22. Phenotypic correlation between body weight and body measurements in Sirohi goats

Age group	No. of observations	Body height	Body length	Body girth
At birth	3527	0.9312**	0.8484**	0.8856**
3 months	3042	0.9691**	0.8066*	0.9899**
6 months	2194	0.9874**	0.7174**	0.8984**
9 months	1624	0.9809**	0.7354**	0.8839**
12 months	1109	0.9909**	0.9078**	0.9819**

NOTE: ** = Highly significant (P≤0.01), * = Significant (P≤0.05)

Regression equations which are predicting the dependent variable body weight from body parameters (body height, body girth and body length) and coefficient of determination are presented in Table 4.23. Only the best-fitted regression models in each group were included in the table. Body length was found to be poor predictor for estimation of body weight. In a multiple regression analysis the important thing to be considered was which independent variables were most considered in determining the dependent variable. The coefficient of determination (R^2) indicates the body measurements success to describe variation in

live weight. The variation of body weight due to body measurements differed between age group. Thus body girth and body height accounted 99.60 & 99.40 per cent of the total variation in body weight; together with total variation of 99.60 percent and for all three measurements with 99.60 per cent of total variations in Sirohi goats. This indicated that involvement of some other factors in estimating the body weights and among those the major one may be feed and water intake status of animals. The association of body weights with body measurements was of course due to contribution in body weight by the body measurements.

It is clear that maximum value of R^2 was obtained by combination of more than one estimates of body measurements so this indicated that weight can be estimated more accurately by combination of two or more than two factors than only one. This study also reported by Thiruvenkadan (2005) in Kanni Adu kids, Moaeen-ud-Din *et al.* (2006), Alex *et al*. (2010), Chitra *et. al.* (2012) in Malabari goats,

Table No. 4.23. Prediction equation of body weight and coefficient of determination (R2) at different age groups

Age group	Equation	R^2
At birth	Y = -4.09786-6.19700921+0.30677321BH-0.00339354BL+ 0.09666917BG	0.996
	Y = -4.09597-6.19792841+ 0.30641005BH+ 0.09393138BG	0.996
	Y = -3.48674-6.45888533+ 0.38975546 BH	0.996
	Y = -3.66364-6.34317802+ 0.39049699BG	0.994
3 month	Y = -4.09786-3.31595442+0.30677321BH-0.00339354BL+ 0.09666917BG	0.996
	Y = -4.09597--3.31400380+ 0.30641005BH+ 0.09393138BG	0.996
	Y = -3.48674-3.35243241 + 0.38975546 BH	0.996
	Y = -3.66364-3.28005470 +0.39049699BG	0.994
6 month	Y = -4.09786-1.90037012+0.30677321BH-0.00339354BL+ 0.09666917BG	0.996
	Y = -4.09597-1.89967441 + 0.30641005BH+ 0.09393138BG	0.996
	Y = -3.48674-1.84590258 + 0.38975546 BH	0.996
	Y = -3.66364-1.88938508 +0.39049699BG	0.994
9 month	Y = -4.09786+0.49862466 +0.30677321BH-0.00339354BL+ 0.09666917BG	0.996
	Y = -4.09597+0.49813698 + 0.30641005BH+ 0.09393138BG	0.996
	Y = -3.48674+0.59544640 + 0.38975546 BH	0.996
	Y = -3.66364+0.54649326 +0.39049699BG	0.994
12 month	Y = -4.09786+10.91470909+0.30677321BH-0.00339354BL+ 0.09666917BG	0.996
	Y = -4.09597+10.91346964 + 0.30641005BH+ 0.09393138BG	0.996
	Y = -3.48674+11.06177392 + 0.38975546 BH	0.996
	Y = -3.66364+10.96612455+ 0.39049699BG	0.994

Where Y= Body weight (Kg), BH = Body height (cm), BL = Body length (cm) and BG = Body girth (cm).

4.9.1 Predicted body weight from prediction equations

Predicted weight in different regression equations of Sirohi goats is presented in Table 4.24, 4.25 and 4.26. But there was a difference in range values in each equation and the approximation to the actual was observed in equations with high R^2. In all the age groups there was no significant difference between actual weight and predicted weight. But there was a difference in range values in each equation and the approximation to the actual was observed in equations with high R^2. The equations with larger R^2 showed similar to the range observed in actual weight category.

Highly significant (P≤ 0.01) effect of sire was estimated at birth, 3, 6 and 12 months of age also cluster wise variation was highly significant (P≤ 0.01) at birth and 3 months, significant (P≤ 0.05) at 9 and 12 months, non-significant at 6 months on predicted body weight by equations presented in Table 4.24 and 4.25.

Effect of season was highly significant (P≤ 0.01) at birth and 3 months, non-significant at 6, 9 and 12 months predicted body weight, year of birth was highly significant (P≤ 0.01) on all age group of predicted body weight, parity of dam was non-significant on all age group of predicted body weight, type of birth was non-significant on all age group except at 12 months of predicted body weight, sex of kid was highly significant (P≤ 0.01) on all age group except at 12 months, which was non-significant, dam's weight at kidding was non-significant except at 6 months of predicted body weight by equations presented in Table 4.24, 4.25 and 4.26.

Highly significant (P≤ 0.01) effect of sire was estimated at birth, 3, 6 and 12 months of age and significant (P≤ 0.05) at 9 months of age on predicted body weight by equation presented in Table 4.26.

Table No. 4.24. Least-squares means and S.E. for predicted body weights (kg) of Sirohi goat at different ages (#)

Traits / Factors	At birth	3 month	6 month	9 month	12 month
Overall mean (μ)	2.86 ± 0.07 (3459)	13.75 ± 0.13 (2894)	17.94 ± 0.14 (1994)	22.21 ± 0.29 (1541)	34.08 ± 0.24 (1013)
Sire	**	**	**	NS	**
Cluster	**	**	NS	*	*
Vallabhnagar	2.95 ± 0.10 (260)	13.99 ± 0.20 (210)	17.80 ± 0.24 (118)	21.73 ± 0.40 (59)	33.46 ± 1.02 (36)
Railmagra	2.43 ± 0.10 (643)	13.31 ± 0.19 (589)	17.48 ± 0.22 (496)	22.58 ± 0.35 (394)	34.14 ± 0.48 (227)
Devgarh	2.40 ± 0.10 (1547)	13.28 ± 0.19 (1385)	17.49 ± 0.22 (1081)	21.63 ± 0.36 (889)	33.26 ± 0.48 (654)
Nathdwara	3.75 ± 0.28 (33)	14.09 ± 0.58 (15)	18.99 ± 0.64 (12)	22.81 ± 1.18 (3)	----
Bhadsoda	2.77 ± 0.10 (976)	14.05 ± 0.19 (695)	17.96 ± 0.24 (287)	22.28 ± 0.39 (196)	35.48 ± 0.59 (96)
Season	**	**	NS	NS	NS
Rainy	2.88 ± 0.07 (1284)	13.85 ± 0.13 (1116)	17.94 ± 0.14 (690)	22.25 ± 0.31 (487)	34.09 ± 0.25 (326)
Winter	2.92 ± 0.07 (1664)	13.82 ± 0.14 (1329)	17.99 ± 0.15 (955)	22.23 ± 0.30 (784)	34.11 ± 0.25 (530)
Summer	2.78 ± 0.07 (511)	13.57 ± 0.14 (449)	17.90 ± 0.16 (349)	22.14 ± 0.30 (270)	34.05 ± 0.29 (157)
Period	**	**	**	**	**
2007-08	2.52 ± 0.09 (482)	13.13 ± 0.18 (442)	17.11 ± 0.20 (395)	21.90 ± 0.35 (349)	33.39 ± 0.37 (289)
2008-09	2.72 ± 0.09 (569)	13.50 ± 0.18 (520)	17.56 ± 0.20 (385)	22.04 ± 0.35 (290)	33.36 ± 0.36 (180)
2009-10	2.80 ± 0.08 (603)	13.62 ± 0.15 (500)	17.80 ± 0.16 (370)	21.80 ± 0.31 (306)	33.89 ± 0.31 (182)
2010-2011	2.85 ± 0.08 (527)	13.58 ± 0.16 (435)	17.91 ± 0.18 (347)	21.48 ± 0.33 (293)	34.71 ± 0.35 (198)
2011-2012	3.00 ± 0.08 (660)	13.90 ± 0.16 (536)	18.00 ± 0.17 (359)	21.88 ± 0.33 (277)	35.07 ± 0.36 (164)
2012-2013	3.28 ± 0.08 (618)	14.74 ± 0.17 (461)	19.27 ± 0.21 (138)	24.14 ± 0.49 (26)	----
Year of birth	NS	NS	NS	NS	NS
1st	2.83 ± 0.07 (761)	13.81 ± 0.14 (631)	17.86 ± 0.16 (465)	22.17 ± 0.31 (374)	34.05 ± 0.29 (248)
2nd	2.88 ± 0.07 (655)	13.77 ± 0.14 (562)	17.99 ± 0.16 (409)	22.29 ± 0.31 (323)	34.03 ± 0.28 (218)
3rd	2.86 ± 0.07 (598)	13.73 ± 0.14 .(521)	17.91 ± 0.16 (375)	22.04 ± 0.31 (283)	34.04 ± 0.28 (194)
4th	2.87 ± 0.07 (518)	13.78 ± 0.14 (435)	18.03 ± 0.16 (287)	22.29 ± 0.32 (209)	34.13 ± 0.30 (135)
≥ 5th	2.87 ± 0.07 (927)	13.63 ± 0.14 (745)	17.91 ± 0.15 (458)	22.24 ± 0.31 (352)	34.17 ± 0.28 (218)

Type of birth	NS	NS	NS	NS	*
Single	2.87 ± 0.07 (2005)	13.79 ± 0.13 (1722)	17.95 ± 0.14 (1244)	22.26 ± 0.29 (977)	34.25 ± 0.25 (662)
Multiple	2.86 ± 0.07 (1454)	13.71 ± 0.14 (1172)	17.93 ± 0.15 (750)	22.16 ± 0.30 (564)	33.92 ± 0.26 (351)
Sex	**	**	**	**	NS
Male	2.99 ± 0.07 (1709)	13.98 ± 0.13 (1377)	18.23 ± 0.14 (876)	22.58 ± 0.30 (605)	34.21 ± 0.26 (285)
Female	2.74 ± 0.07 (1750)	13.51 ± 0.13 (1517)	17.65 ± 0.14 (1118)	21.83 ± 0.30 (936)	33.95 ± 0.24 (728)
Regression on weight of dam at kidding	NS	NS	*	NS	NS
Regression coefficient (b) (kg/kg)	- 0.012 ± 0.007	-0.0001 ± 0.015	-0.0403 ± 0.018	-0.0314 ± 0.026	-0.034 ± 0.039

NOTE: ** = Highly significant (P≤0.01), * = Significant (P≤0.05), NS = Non-significant, # = Y = A1 +0.30677321BH-0.00339354BL+ 0.09666917BG (A1 = -10.2949 for birth, -7.41381 for 3 months, -5.99823 for 6 months, -3.59924 for 9 months, 6.816849 for 12 moths age.)

Table No. 4.25. Least-squares means and S.E. for predicted body weights (kg) of Sirohi goat at different ages (#)

Traits / Factors	At birth	3 month	6 month	9 month	12 month
Overall mean (μ)	2.86 ± 0.07 (3459)	13.75 ± 0.13 (2894)	17.94 ± 0.14 (1994)	22.20 ± 0.29 (1541)	34.09 ± 0.24 (1013)
Sire	**	**	**	NS	**
Cluster	**	**	NS	*	*
Vallabhnagar	2.96 ± 0.10 (260)	13.99 ± 0.20 (210)	17.80 ± 0.24 (118)	21.73 ± 0.40 (59)	33.47 ± 1.02 (36)
Railmagra	2.43 ± 0.10 (643)	13.31 ± 0.19 (589)	17.48 ± 0.22 (496)	22.58 ± 0.35 (394)	34.14 ± 0.48 (227)
Devgarh	2.40 ± 0.10 (1547)	13.28 ± 0.19 (1385)	17.49 ± 0.22 (1081)	21.63 ± 0.36 (889)	33.26 ± 0.48 (654)
Nathdwara	3.75 ± 0.28 (33)	14.09 ± 0.58 (15)	18.99 ± 0.65 (12)	22.80 ± 1.18 (3)	----
Bhadsoda	2.77 ± 0.10 (976)	14.05 ± 0.19 (695)	17.96 ± 0.24 (287)	22.28 ± 0.39 (196)	35.48 ± 0.59 (96)
Season	**	**	NS	NS	NS
Rainy	2.88 ± 0.07 (1284)	13.84 ± 0.13 (1116)	17.94 ± 0.14 (690)	22.25 ± 0.31 (487)	34.09 ± 0.25 (326)
Winter	2.92 ± 0.07 (1664)	13.82 ± 0.13 (1329)	17.99 ± 0.15 (955)	22.23 ± 0.30 (784)	34.11 ± 0.25 (530)
Summer	2.78 ± 0.07 (511)	13.57 ± 0.14 (449)	17.90 ± 0.16 (349)	22.14 ± 0.30 (270)	34.06 ± 0.29 (157)
Year of birth	**	**	**	**	**
2007-08	2.52 ± 0.09 (482)	13.13 ± 0.18 (442)	17.11 ± 0.20 (395)	21.90 ± 0.35 (349)	33.39 ± 0.37 (289)
2008-09	2.72 ± 0.09 (569)	13.50 ± 0.18 (520)	17.56 ± 0.20 (385)	22.04 ± 0.35 (290)	33.36 ± 0.36 (180)
2009-10	2.80 ± 0.08 (603)	13.62 ± 0.15 (500)	17.80 ± 0.16 (370)	21.80 ± 0.31 (306)	33.89 ± 0.31 (182)
2010-2011	2.85 ± 0.08 (527)	13.58 ± 0.16 (435)	17.91 ± 0.18 (347)	21.48 ± 0.33 (293)	34.71 ± 0.35 (198)
2011-2012	3.00 ± 0.08 (660)	13.90 ± 0.16 (536)	18.00 ± 0.17 (359)	21.88 ± 0.33 (277)	35.07 ± 0.36 (164)
2012-2013	3.28 ± 0.08 (618)	14.74 ± 0.17 (461)	19.27 ± 0.21 (138)	24.13 ± 0.49 (26)	----
Parity	NS	NS	NS	NS	NS
1^{st}	2.83 ± 0.07 (761)	13.81 ± 0.14 (631)	17.86 ± 0.16 (465)	22.17 ± 0.31 (374)	34.05 ± 0.29 (248)
2^{nd}	2.88 ± 0.07 (655)	13.77 ± 0.14 (562)	17.99 ± 0.16 (409)	22.29 ± 0.31 (323)	34.03 ± 0.28 (218)
3^{rd}	2.86 ± 0.07 (598)	13.73 ± 0.14 (521)	17.91 ± 0.16 (375)	22.03 ± 0.31 (283)	34.04 ± 0.28 (194)
4^{th}	2.86 ± 0.08 (518)	13.78 ± 0.14 (435)	18.03 ± 0.16 (287)	22.29 ± 0.32 (209)	34.13 ± 0.30 (135)
≥ 5^{th}	2.87 ± 0.07 (927)	13.63 ± 0.14 (745)	17.91 ± 0.15 (458)	22.24 ± 0.31 (352)	34.17 ± 0.28 (218)

Type of birth	NS	NS	NS	NS	*
Single	2.87 ± 0.07 (2005)	13.79 ± 0.13 (1722)	17.95 ± 0.14 (1244)	22.25 ± 0.29 (977)	34.25 ± 0.25 (662)
Multiple	2.86 ± 0.07 (1454)	13.71 ± 0.14 (1172)	17.93 ± 0.15 (750)	22.16 ± 0.30 (564)	33.92 ± 0.26 (351)
Sex	**	**	**	**	NS
Male	2.99 ± 0.07 (1709)	13.98 ± 0.13 (1377)	18.23 ± 0.14 (876)	22.58 ± 0.30 (605)	34.22 ± 0.26 (285)
Female	2.74 ± 0.07 (1750)	13.51 ± 0.13 (1517)	17.65 ± 0.14 (1118)	21.83 ± 0.29 (936)	33.95 ± 0.24 (728)
Regression on weight of dam at kidding	NS	NS	*	NS	NS
Regression coefficient (b) (kg/kg)	-0.012 ± 0.007	-0.0001 ± 0.015	-0.0402 ± 0.018	-0.031 ± 0.026	-0.035 ± 0.039

NOTE: ** = Highly significant (P≤0.01), * = Significant (P≤0.05), NS = Non-significant,

= Y = A2+ 0.30641005BH+ 0.09393138BG (A2 = -10.2939 for birth, -7.40997 for 3 months, -5.99564 for 6 months, -3.59783 for 9 months, 6.8175 for 12 months age)

Table No. 4.26. Least-squares means and S.E. for predicted body weights (kg) of Sirohi goat at different ages (#)

Traits / Factors	At birth	3 month	6 month	9 month	12 month
Overall mean (μ)	2.86 ± 0.07 (3459)	13.73 ± 0.13 (2894)	17.95 ± 0.14 (1994)	22.25 ± 0.30 (1541)	34.08 ± 0.24 (1013)
Sire	**	**	**	*	**
Cluster	**	**	*	*	*
Vallabhnagar	2.96 ± 0.10 (260)	13.99 ± 0.20 (210)	17.80 ± 0.23 (118)	21.82 ± 0.40 (59)	33.50 ± 1.01 (36)
Railmagra	2.47 ± 0.10 (643)	13.32 ± 0.19 (589)	17.48 ± 0.22 (496)	22.58 ± 0.35 (394)	34.09 ± 0.48 (227)
Devgarh	2.40 ± 0.10 (1547)	13.28 ± 0.19 (1385)	17.48 ± 0.21 (1081)	21.61 ± 0.36 (889)	33.26 ± 0.48 (654)
Nathdwara	3.70 ± 0.28 (33)	14.03 ± 0.59 (15)	19.08 ± 0.63 (12)	22.92 ± 1.16 (3)	----
Bhadsoda	2.76 ± 0.10 (976)	14.05 ± 0.19 (695)	17.93 ± 0.24 (287)	22.34 ± 0.39 (196)	35.48 ± 0.58 (96)
Season	**	**	NS	NS	NS
Rainy	2.87 ± 0.07 (1284)	13.83 ± 0.13 (1116)	17.95 ± 0.14 (690)	22.29 ± 0.31 (487)	34.09 ± 0.25 (326)
Winter	2.92 ± 0.07 (1664)	13.81 ± 0.14 (1329)	18.01 ± 0.14 (955)	22.28 ± 0.31 (784)	34.11 ± 0.25 (530)
Summer	2.78 ± 0.07 (511)	13.57 ± 0.14 (449)	17.90 ± 0.15 (349)	22.19 ± 0.31 (270)	34.04 ± 0.29 (157)
Year of birth	**	**	**	**	**
2007-08	2.52 ± 0.09 (482)	13.11 ± 0.18 (442)	17.14 ± 0.19 (395)	21.95 ± 0.35 (349)	33.40 ± 0.36 (289)
2008-09	2.71 ± 0.09 (569)	13.49 ± 0.18 (520)	17.61 ± 0.19 (385)	22.09 ± 0.35 (290)	33.39 ± 0.36 (180)
2009-10	2.80 ± 0.07 (603)	13.62 ± 0.15 (500)	17.81 ± 0.16 (370)	21.87 ± 0.31 (306)	33.90 ± 0.31 (182)
2010-2011	2.85 ± 0.08 (527)	13.56 ± 0.16 (435)	17.88 ± 0.17 (347)	21.51 ± 0.33 (293)	34.70 ± 0.34 (198)
2011-2012	2.99 ± 0.08 (660)	13.90 ± 0.16 (536)	17.98 ± 0.17 (359)	21.89 ± 0.33 (277)	35.02 ± 0.36 (164)
2012-2013	3.27 ± 0.08 (618)	14.72 ± 0.17 (461)	19.30 ± 0.20 (138)	24.21 ± 0.49 (26)	----
Parity	NS	NS	NS	NS	NS
1st	2.82 ± 0.07 (761)	13.80 ± 0.14 (631)	17.89 ± 0.15 (465)	22.22 ± 0.32 (374)	34.05 ± 0.28 (248)
2nd	2.87 ± 0.07 (655)	13.75 ± 0.14 (562)	18.01 ± 0.15 (409)	22.31 ± 0.31 (323)	34.02 ± 0.27 (218)
3rd	2.86 ± 0.07 (598)	13.72 ± 0.14 (521)	17.92 ± 0.15 (375)	22.09 ± 0.32 (283)	34.05 ± 0.28 (194)
4th	2.87 ± 0.07 (518)	13.77 ± 0.14 (435)	18.04 ± 0.15 (287)	22.35 ± 0.32 (209)	34.12 ± 0.29 (135)
≥ 5th	2.87 ± 0.07 (927)	13.62 ± 0.14 (745)	17.92 ± 0.15 (458)	22.30 ± 0.31 (352)	34.16 ± 0.27 (218)

Type of birth	NS	NS	NS	NS	*
Single	2.86 ± 0.07 (2005)	13.77 ± 0.13 (1722)	17.97 ± 0.14 (1244)	22.31 ± 0.30 (977)	34.24 ± 0.24 (662)
Multiple	2.85 ± 0.07 (1454)	13.70 ± 0.14 (1172)	17.94 ± 0.14 (750)	22.20 ± 0.31 (564)	33.92 ± 0.25 (351)
Sex	**	**	**	**	NS
Male	2.98 ± 0.07 (1709)	13.96 ± 0.13 (1377)	18.24 ± 0.14 (876)	22.64 ± 0.30 (605)	34.21 ± 0.26 (285)
Female	2.73 ± 0.07 (1750)	13.51 ± 0.13 (1517)	17.67 ± 0.14 (1118)	21.87 ± 0.30 (936)	33.96 ± 0.23 (728)
Regression on weight of dam at kidding	NS	NS	*	NS	NS
Regression coefficient (b) (kg/kg)	-0.012 ± 0.007	0.0004 ± 0.015	-0.0360 ± 0.018	-0.033 ± 0.026	-0.039 ± 0.039

NOTE: ** = Highly significant (P≤0.01), * = Significant (P≤0.05), NS = Non-significant, # = Y = A3+ 0.38975546 BH (A3 = -9.94563 for birth, -6.83917 for 3 months, -5.33264 for 6 months, -2.89129 for 9 months, 7.575034 for 12 months age)

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Studies on Growth, Productive and Reproductive Performance of Sirohi Goats around Udaipur District of Rajasthan under Field Condition

Ph. D. Thesis

Department of Animal Breeding and Genetics

College of Veterinary and Animal Science

Rajasthan University of Veterinary and Animal Sciences,

Bikaner-334 001

Submitted by: Dudhe Shashank Deorao

Guided by: Dr. S.B.S. Yadav

ABSTRACT

For present investigation, the detailed information of 3551 Sirohi goats regarding growth, production and reproduction traits, during the period from 2007 to 2013, maintained at villages situated in Nathdwara, Railmagra and Devgarh clusters of Rajsamand district, Bhadsoda cluster of Chittorgarh district and Vallabhnagar cluster of Udaipur district, maintained under ICAR sponsored All India Co-ordinated Research Project (AICRP) on Sirohi goats, Livestock Research Station, Udaipur (Rajasthan) were analyzed.

The overall least-squares means for body weights were observed to be 2.55 ± 0.05, 13.30 ± 0.47, 16.96 ± 0.52, 20.98 ± 1.05 and 25.80 ± 0.49 kg at birth, 3, 6, 9 and 12 months of ages, respectively.

The effect of sire, cluster, year of birth, type of birth and sex of kid were observed as highly significant (P≤ 0.01) on body weight at birth, 3, 6, 9 and 12 months of ages. Effect of season was highly significant (P≤ 0.01) on 3 and 9 months of age, significant (P≤ 0.05) on

12 months of age while non-significant at birth and 6 months of age. The effect of parity was non-significant on body weights at all ages. The effect of dam's weight as a covariate had positive and highly significant (P≤ 0.01) effect on birth and 3 months body weight, significant (P≤ 0.05) effect on 12 months body weights and non-significant on 6 and 9 body months body weights.

The heritability estimates for body weight at birth, 3, 6, 9 and 12 months of ages were 0.318 ± 0.063, 0.693 ± 0.115, 0.563 ± 0.105, 0.560 ± 0.112 and 0.475 ± 0.111, respectively. Estimates of genetic correlations between body weights at different ages ranged from 0.245 ± 0.175 to 0.926 ± 0.038. Estimates for phenotypic correlations between body weights at different ages ranged from 0.161 ± 0.028 to 0.685 ± 0.015.

The overall least-squares means for body measurements were observed to be 31.02 ± 0.35, 51.53 ± 1.19, 57.65 ± 0.95, 61.76 ± 2.24 and 67.09 ± 0.95 cm for body height; 28.29 ± 0.39, 47.90 ± 1.20, 53.96 ± 1.01, 57.36 ± 2.16 and 62.65 ± 098 cm for body length; 31.19 ± 0.41, 51.62 ± 1.18, 58.64 ± 1.00, 62.26 ± 2.35 and 67.51± 1.06 cm for body girth at birth, 3, 6, 9 and 12 months of ages, respectively.

The effect of sire, cluster, year of birth, type of birth and sex of kid were observed as highly significant (P≤ 0.01) effect on all three morphometric traits. Effect of season was highly significant (P≤ 0.01) effect on 3 and 12 months of age for body height; at birth and 3 months of age for body length; at birth, 3 and 12 months of age for body girth, significant (P≤ 0.05) effect at birth and 9 months of age for body height; non-significant on 6, 9 and 12 months of age for body length; 6 and 9 months of age for body girth. Parity was highly significant (P≤ 0.01) effect at birth for body height and body girth; non-significant on 3,6, 9 and 12 months of age for body height and body girth, whereas body length was non-significant on all stages of age. The effect of dam's weight at kidding had positive and highly significant (P≤ 0.01) effect on birth and 12 months of ages for body height and body length; 12

months of age for body girth; significant (P≤ 0.05) effect on 3 and 6 months of ages for body height; at 6 months of age for body length; at birth and 3 months of ages for body girth; non-significant on 9 month of age for body height; on 3 and 9 months of ages for body length; on 6 and 9 months of ages for body girth.

The heritability estimates at birth, 3, 6, 9 and 12 months of ages for body height were 0.693 ± 0.130, 0.528 ± 0.163, 0.709 ± 0.144, 0.699 ± 0.179 and 0.708 ± 0.188; 0.568 ± 0 .137, 0.408 ± 0.159, 0.589 ± 0.150, 0.571 ± 0.172 and 0.605 ± 0.192 for body length and 0.590 ± 0.147, 0.695 ± 0.161, 0.563 ± 0.138, 0.676 ± 0.184 and 0.503 ± 0.197 for body girth, respectively.

Estimates of genetic correlations between body heights at different ages ranged from 0.520 ± 0.030 to 0.775 ± 0.014. Estimates for phenotypic correlations between body heights at different ages ranged from 0.333 ± 0.026 to 0.741 ± 0.013; Estimates of genetic correlations between body lengths at different ages ranged from 0.478 ± 0.126 to 0.863 ± 0.050. Estimates for phenotypic correlations between body lengths at different ages ranged from 0.227 ± 0.028 to 0.703 ± 0.015; Estimates of genetic correlations between body girths at different ages ranged from 0.508 ± 0.061 to 0.900 ± 0.044. Estimates for phenotypic correlations between body girths at different ages ranged from 0.340 ± 0.026 to 0.668 ± 0.017.

The overall least-squares means for average test day milk yield, 90 days milk yield, 150 days milk yield, total milk yield, lactation length and dry period were observed to be 0.604 ± 0.02 litre, 61.79 ± 2.48 litre, 90.96 ± 2.58 litre, 91.08 ± 2.56 litre, 150.75 ± 0.72 days and 151.63 ± 14.25 days, respectively.

The effect of sire, cluster and year of birth were observed as highly significant (P≤ 0.01) effect on all production traits. Effect of season was highly significant (P≤ 0.01) effect on average test day milk

yield, 90 days milk yield, 150 days milk yield and lactation length; significant (P≤ 0.05) effect on total milk yield; non-significant on dry period. Parity was highly significant (P≤ 0.01) effect on all production traits except lactation length which was non-significant. Type of birth had significant (P≤ 0.05) effect on 90 days milk yield; non-significant effect on 150 days milk yield, total milk yield, lactation length and dry period. The effect of dam's weight at kidding had positive and highly significant (P≤ 0.01) effect on all production traits except lactation length which was non-significant.

The heritability estimates for average test day milk yield, 90 days milk yield, 150 days milk yield, total milk yield, lactation length and dry period were 0.442 ± 0.100, 0.652 ± 0.101, 0.614 ± 0.108, 0.594 ± 0.106, 0.475 ± 0.095 and 0.391 ± 0.087. Estimates of genetic correlations between production traits ranged from -0.463 ± 0.156 to 0.686 ± 0.042. Estimates for phenotypic correlations between production traits ranged from -0.116 ± 0.040 to 0.696 ± 0.010.

The overall least-squares means for age at first conception, weight at first conception, age at first kidding, weight at first kidding, gestation period and kidding interval were observed to be 523.81± 38.93 days, 27.54 ± 0.19 kg, 672.63 ± 38.95 days, 31.10 ± 0.41 kg, 148.82 ± 0.31 days and 290.61± 11.38 days, respectively.

The effect of sire was observed as highly significant (P≤ 0.01) effect on age at first conception, age at first kidding, weight at first kidding and gestation period; significant (P≤ 0.05) effect on weight at first conception. Cluster-wise variation was observed as highly significant (P≤ 0.01) effect on weight at first conception, weight at first kidding and gestation period; significant (P≤ 0.05) effect on age at first conception and age at first kidding. The effect of year of kidding was observed as highly significant (P≤ 0.01) effect on all reproduction traits except kidding interval. Season of kidding was observed as highly

significant (P≤ 0.01) effect on age at first conception, age at first kidding, gestation period and kidding interval. Year of birth was observed as highly significant (P≤ 0.01) effect on all reproduction traits except gestation period and kidding interval, which was non-significant. Season of birth was observed as highly significant (P≤ 0.01) effect on kidding interval; significant (P≤ 0.05) effect on weight at first kidding. The effect of dam's weight at kidding had positive and highly significant (P≤ 0.01) effect on age at first conception, weight at first conception and age at first kidding.

The heritability estimates for age at first conception, weight at first conception, age at first kidding, weight at first kidding, gestation period and kidding interval were 0.502 ± 0.178, 0.104 ± 0.124, 0.501 ± 0.178, 0.331 ± 0.147 and 0.235 ± 0.124. Estimates of genetic correlations between reproduction traits ranged from -0.228 ± 0.568 to 0.590 ± 0.249. Estimates for phenotypic correlations between reproduction traits ranged from -0.029 ± 0.043 to 0.501 ± 0.033.

The phenotypic correlations of body measurements with body weight were positive, and highly significant (P≤ 0.01). Among the three body measurements body height had maximum correlation with body weight followed by body girth and body length. Body length was found to be poor predictor for estimation of body weight. It is clear that maximum value of R^2 was obtained by combination of more than one estimates of body measurements so this indicated that weight can be estimated more accurately by combination of two or more than two factors than only one.

राजस्थान के उदयपुर जिले की क्षेत्रिय परिस्थितियों मे सिरोही बकरियों की शारीरिक वृद्धि, उत्पादक और प्रजनन प्रदर्शन पर अध्ययन

विद्या वाचस्पति शोध प्रबन्ध

पशु प्रजनन एंव आनुवांशिकी विभाग

पशुचिकित्सा एंव पशु विज्ञान महाविद्यालय

राजस्थान पशुचिकित्सा एंव पशु विज्ञान विश्वविद्यालय, बीकानेर- 334001

प्रस्तुतकर्ता: **दुधे शशांक देवराव**

मुख्य उपदेष्टा : **डॉ॰ एस॰ बी॰ एस॰ यादव**

अनुक्षेपन

वर्ष 2007 से 2013 की अवधि में शारीरिक वृद्धि, उत्पादक और प्रजनन प्रदर्शन के बारे में 3551 सिरोही बकरियों की विस्तृत जानकारी के लिए राजसमंद जिले के नाथद्वारा, रेलमगरा और देवगढ़ ग्राम समूहों, चित्तौड़गढ़ जिले के भदसोड़ा और उदयपुर जिले के वल्लभनगर ग्राम समूह में भारतीय कृषि अनुसंधान परिषद व्दारा प्रायोजित सिरोही बकरियों पर अखिल भारतीय समन्वित अनुसंधान परियोजना (एआईसीआरपी), पशुधन अनुसंधान केन्द्र, वल्लभनगर, उदयपुर (राजस्थान) के तहत अध्ययन किया गया।

सिरोही बकरी के बच्चों का जन्म के समय व 3, 6, 9 तथा 12 माह की आयु पर औसत शारीरिक भार 2.55 ± 0.05, 13.30 ± 0.47, 16.96 ± 0.52, 20.98 ± 1.05 तथा 25.80 ± 0.49 किलोग्राम आँका गया।

प्रजनक बकरे, ग्राम समूह, जन्म वर्ष, जन्म के प्रकार और बच्चे के लिंग का प्रभाव जन्म, 3, 6, 9 और 12 महीने के आयु के शारीरिक भार पर अति अर्थपूर्ण ($P \leq 0.01$) था। मौसम का प्रभाव उम्र के 12 महीनों के शारीरिक भार पर अर्थपूर्ण ($P \leq 0.05$) तथा उम्र के 3 और 9 महीने पर अति अर्थपूर्ण ($P \leq 0.01$) था, जबकि जन्म और 6 महीने के शारीरिक भार पर मौसम का प्रभाव अर्थपूर्ण नहीं था। माता के

ब्यांत-क्रम का प्रभाव किसी भी उम्र के वजन पर अर्थपूर्ण नहीं था। प्रसव के समय माता के शारीरिक भार का बच्चों के जन्म और 3 महीने के शारीरिक भार पर प्रभाव सकारात्मक तथा अति अर्थपूर्ण ($P \leq 0.01$), 12 महीने के शारीरिक भार पर प्रभाव अर्थपूर्ण ($P \leq 0.05$) तथा 6 और 9 महीनों के शारीरिक भार पर अर्थहिन पाया गया।

जन्म, 3, 6, 9 और 12 महीनों के शारीरिक भार की आनुवांशिकता का अनुमान क्रमशः 0.318 ± 0.063, 0.693 ± 0.115, 0.563 ± 0.105, 0.560 ± 0.112 और 0.475 ± 0.111 था। विभिन्न आयु के शारीरिक भार के बीच आनुवंशिक सह-संबंध का अनुमान 0.245 ± 0.175 से 0,926 ± 0.038 तक तथा प्रादुषिक सह-संबंध के लिए अनुमान 0.161 ± 0,028 से 0.685 ± 0.015 तक पाया गया।

जन्म, 3, 6, 9 और 12 माह की आयु पर शरीर की औसत ऊंचाई क्रमशः 31.02 ± 0.35, 51.53 ± 1.19, 57.65 ± 0.95, 61.76 ± 2.24 और 67.09 ± 0.95 सेमी; औसत लंबाई क्रमशः 28.29 ± 0.39, 47.90 ± 1.20, 53.96 ± 1.01, 57.36 ± 2.16 और 62.65 ± 098 सेमी; तथा औसत सीने का घेरा क्रमशः 31.19 ± 0.41, 51.62 ± 1.18, 58.64 ± 1.00, 62.26 ± 2.35 और 67.51± 1.06 सेमी आँका गया।

प्रजनन बकरे, समूह, जन्म का वर्ष, जन्म के प्रकार और बच्चे के लिंग के प्रकार का प्रभाव जन्म के समय, 3, 6, 9 और 12 महीने के आयु पर तीनों शारीरिक माप पर अति अर्थपूर्ण ($P \leq 0.01$) था। शारीरिक माप पर मौसम का प्रभाव उम्र के 3 और 12 महीनों पर अति अर्थपूर्ण ($P \leq 0.01$) शरीर की ऊंचाई के लिए; जन्म के समय और 3 माह की आयु पर शरीर की लंबाई के लिए; जन्म के समय, 3 और 12 माह की आयु पर शरीर के घेरे के लिए, शारीरिक माप पर मौसम का प्रभाव जन्म के समय और 9 माह की आयु पर अर्थपूर्ण ($P \leq 0.05$) शरीर की ऊंचाई के लिए; जबकि उम्र के 6, 9 और 12 माह की आयु पर शरीर की लंबाई; उम्र के 6 और 9 माह की आयु पर शरीर का घेर अर्थपूर्ण नहीं था। माता के ब्यांत-क्रम का प्रभाव जन्म के समय पर शरीर की ऊंचाई के लिए और शरीर के घेरे के लिए अति अर्थपूर्ण ($P \leq 0.01$) रहा; उम्र के 3, 6, 9 और 12 माह की आयु पर शरीर की ऊंचाई और शारीरिक घेर पर अर्थपूर्ण नहीं था जबकि शरीर की लंबाई किसीभी उम्र पर अर्थपूर्ण नहीं थी। प्रसव के समय माता के शारीरिक भार का बच्चों के जन्म और 12 महीने

की शरीर की ऊंचाई और शरीर की लंबाई पर प्रभाव सकारात्मक तथा अति अर्थपूर्ण (P≤ 0.01) रहा; 3 और 6 माह की आयु पर शरीर की ऊंचाई, 6 माह की आयु पर शरीर की लंबाई और जन्म के समय, 3 माह की आयु पर शरीर का घेर अर्थपूर्ण (P≤ 0.05) रहा। जबकि 9 माह की आयु पर शरीर की ऊंचाई; 3 और 9 माह की आयु पर शरीर की लंबाई और 6 और 9 माह की आयु पर शरीर का घेर अर्थपूर्ण नहीं था।

जन्म के समय, 3, 6, 9 और 12 महीनों के उम्र पर शरीर की ऊंचाई की आनुवांशिकता अनुमान 0.693 ± 0.130, 0.528 ± 0.163, 0.709 ± 0.144, 0.699 ± 0.179 और 0.708 ± 0.188; शरीर की लंबाई की 0.568 ± 0 .137, 0.408 ± 0.159, 0.589 ± 0.150, 0.571 ± 0.172 और 0.605 ± 0.192 और शरीर के घेरे की 0.590 ± 0.147, 0.695 ± 0.161, 0.563 ± 0.138, 0.676 ± 0.184 और 0.503 ± 0.197, क्रमशः आँका गया। अलग अलग उम्र में शरीर की ऊंचाई के बीच आनुवंशिक सह-संबंध का अनुमान 0.520 ± 0.030 से 0.775 ± 0.014; शरीर की लंबाई के बीच 0.478 ± 0.126 से 0.863 ± 0.050 और शरीर का घेरे के बीच 0.508 ± 0.061 से 0.900 ± 0.044 तक बताया गया। अलग अलग उम्र में शरीर की ऊंचाई के बीच प्ररूपी सह-संबंध के लिए अनुमान 0.333 ± 0.026 से 0.741 ± 0.013; शरीर की लंबाई के बीच 0.227 ± 0.028 से 0.703 ± 0.015 और शरीर का घेरे के बीच 0.340 ± 0.026 से 0.668 ± 0.017 तक बताया गया।

औसत परीक्षण के दिन दूध का उत्पादन, 90 दिनों के दुग्ध उत्पादन, 150 दिन दूध का उत्पादन, कुल दुग्ध उत्पादन, स्तनपान लंबाई और शुष्क अवधि क्रमशः 0.604 ± 0.02 लीटर, 61.79 ± 2.48 लीटर, 90.96 ± 2.58 लीटर, 91.08 ± 2.56 लीटर, 150.75 ± 0.72 दिन और 151.63 ± 14.25 दिन आँका गया।

प्रजनन बकरे, समूह और जन्म का वर्ष के प्रभाव सभी उत्पादन लक्षण पर अति अर्थपूर्ण (P≤ 0.01) था। परीक्षण के दिन दूध का उत्पादन, 90 दिनों के दुग्ध उत्पादन, 150 दिन दूध का उत्पादन, और स्तनपान लंबाई पर मौसम का प्रभाव अति अर्थपूर्ण (P≤ 0.01); कुल दुग्ध उत्पादन पर अर्थपूर्ण (P≤ 0.05) तथा शुष्क अवधि पर अर्थपूर्ण नहीं पाया गया। माता के ब्यांत-क्रम का प्रभाव सभी उत्पादन मापकों पर अति अर्थपूर्ण (P≤ 0.01) सिवाय स्तनपान काल पर अर्थपूर्ण नहीं था। जन्म के प्रकार का प्रभाव परीक्षण के दिन दूध का उत्पादन और 90 दिनों के दुग्ध उत्पादन पर अर्थपूर्ण (P≤ 0.05); 150 दिन दूध का उत्पादन, कुल दुग्ध उत्पादन, स्तनपान

लंबाई और शुष्क अवधि पर अर्थपूर्ण नहीं पाया गया। प्रसव के समय माता के शारीरिक भार का प्रभाव सभी उत्पादन लक्षण पर अति अर्थपूर्ण ($P \leq 0.01$) सिवाय स्तनपान लंबाई अर्थपूर्ण नहीं पायी गयी।

परीक्षण के दिन दूध का उत्पादन, 90 दिनों के दुग्ध उत्पादन, 150 दिन दूध का उत्पादन, कुल दुग्ध उत्पादन, स्तनपान लंबाई और शुष्क अवधि का आनुवांशिकता अनुमान 0.442 ± 0.100, 0.652 ± 0.101, 0.614 ± 0.108, 0.594 ± 0.106, 0.475 ± 0.095 और 0.391 ± 0.087 क्रमशः आँका गया। उत्पादन गुण के बीच आनुवंशिक सह-संबंध का अनुमान 0.463 ± 0.156 से 0.686 ± 0.042 तक बताया गया। उत्पादन गुण के बीच प्ररूपी सह-संबंध के लिए अनुमान -0.116 ± 0.040 से 0.696 ± 0.010 तक बताया गया।

औसत पहले गर्भाधान उम्र, पहले गर्भाधान वजन, पहले प्रसव की उम्र, पहले प्रसव का वजन, गर्भ काल और प्रसव का अंतराल क्रमशः 523.81 ± 38.93 दिन, 27.54 ± 0.19 किलो, 672.63 ± 38.95 दिन, 31.10 ± 0.41 किलो, 148.82 ± 0.31 दिन and 290.61 ± 11.38 दिन आँका गया।

प्रजनन बकरे का प्रभाव पहले गर्भाधान उम्र, पहले प्रसव की उम्र, पहले प्रसव का वजन और गर्भ काल पर अति अर्थपूर्ण ($P \leq 0.01$); पहले गर्भाधान वजन पर अर्थपूर्ण ($P \leq 0.05$) पाया गया। समूह के लिहाज से भिन्नता का प्रभाव पहले गर्भाधान वजन, पहले प्रसव का वजन और गर्भा काल पर अति अर्थपूर्ण ($P \leq 0.01$); पहले गर्भाधान उम्र और पहले प्रसव की उम्र पर अर्थपूर्ण ($P \leq 0.05$) पाया गया। प्रसव के वर्ष का प्रभाव सभी प्रजनन लक्षण पर अति अर्थपूर्ण ($P \leq 0.01$) था सिवाय प्रसव का अंतराल। प्रसव के मौसम का प्रभाव सभी प्रजनन लक्षण पर अति अर्थपूर्ण ($P \leq 0.01$) था सिवाय गर्भा काल और प्रसव का अंतराल। जन्म का वर्ष के प्रभाव सभी प्रजनन लक्षण पर अति अर्थपूर्ण ($P \leq 0.01$) था सिवाय गर्भा काल और प्रसव का अंतराल। जन्म के मौसम का प्रभाव प्रसव के अंतराल पर अति अर्थपूर्ण ($P \leq 0.01$); पहले प्रसव के वजन का प्रभाव अर्थपूर्ण ($P \leq 0.05$) पाया गया। प्रसव के समय माता के शारीरिक भार का प्रभाव पहले गर्भाधान उम्र, पहले गर्भाधान वजन और पहले प्रसव की उम्र पर सकारात्मक तथा अति अर्थपूर्ण ($P \leq 0.01$) पाया गया।

पहले गर्भाधान उम्र, पहले गर्भाधान वजन, पहले प्रसव की उम्र, पहले प्रसव का वजन, गर्भ काल और प्रसव का अंतराल का आनुवांशिकता अनुमानों $0.502 \pm$

0.178, 0.104 ± 0.124, 0.501 ± 0.178, 0.331 ± 0.147 और 0.235 ± 0.124 क्रमशः आँ ा गया। प्रजनन गुण े बीच आनुवंशि सह-संबंध ा अनुमान -0.228 ± 0.568 से 0.590 ± 0.249 त बताया गया। प्रजनन गुण े बीच प्ररूपी सह-संबंध े लिए अनुमान -0.029 ± 0.043 से 0.501 ± 0.033 त बताया गया।

शरीर े वजन े साथ शरीर माप ी प्ररूपी सहसंबंध स ारात्म और अति महत्वपूर्ण (P≤ 0.01) थे। तीनों शारीरि मापों में से शरीर ी ऊंचाई ा अधि तम सहसंबंध शरीर े वजन से पाया गया क्रमशः शरीर ा घेरा और शरीर ी लंबाई। शरीर ी लंबाई शरीर े वजन े आ लन े लिए ा मजबूत भविष्यवक्ता ह पाया था। यह स्पष्ट हालत है ी R^2 े अधि तम मूल्य शरीर माप े ए से अधि अनुमानों े संयोजन े द्वारा प्राप्त ि या गया त यह वजन े वल ए से द या द से अधि ा र ों े संयोजन े द्वारा और अधि सही अनुमान लगाया जा स ता है।

Studies on Growth, Productive and Reproductive Performance of Sirohi Goats around Udaipur District of Rajasthan under Field Condition

राजस्थान के उदयपुर जिले की क्षेत्रिय परिस्थितियों मे सिरोही बकरियों की शारीरिक वृद्धि, उत्पादक और प्रजनन प्रदर्शन पर अध्ययन

DUDHE SHASHANK DEORAO
M.V.Sc.

THESIS

DOCTOR OF PHILOSOPHY

(Animal Breeding and Genetics)

||पशुधनं नित्यं सर्वलोकोपकारकम्||

2015

Department of Animal Breeding & Genetics
College of Veterinary and Animal Science,
Rajasthan University of Veterinary and Animal Sciences,
Bikaner - 334001

Studies on Growth, Productive and Reproductive Performance of Sirohi Goats around Udaipur District of Rajasthan under Field Condition

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THESIS

Submitted to the
Rajasthan University of Veterinary and Animal Sciences,
Bikaner
In partial fulfilment of the requirements for
the degree of

DOCTOR OF PHILOSOPHY

(Animal Breeding and Genetics)

FACULTY OF VETERINARY & ANIMAL SCIENCES

By

DUDHE SHASHANK DEORAO
M.V.Sc.

2015

Rajasthan University of Veterinary and Animal Sciences

College of Veterinary and Animal Science

Bikaner - 334001

CERTIFICATE - I

Date…...……

This is to certify that **Mr. Dudhe Shashank Deorao** has successfully completed the **comprehensive examination** held on **18-10-2013 to 20-10-2013** as required under the regulations for **Doctor of Philosophy.**

(Dr. G.C. Gahlot)
Head
Department of Animal Breeding & Genetics,
College of Veterinary and Animal Science,
Bikaner

Rajasthan University of Veterinary and Animal Sciences

College of Veterinary and Animal Science

Bikaner - 334001

CERTIFICATE - II

Date.....……

This is to certify that this thesis entitled "**Studies on Growth, Productive and Reproductive Performance of Sirohi Goats around Udaipur District of Rajasthan under Field Condition"** submitted for the degree of **Doctor of Philosophy** in the subject of **Animal Breeding and Genetics** embodies bonafide research work carried-out by **Mr. Dudhe Shashank Deorao** under my guidance and supervision and that no part of this thesis has been submitted for any other degree. The assistance and help received during the course of investigation have been fully acknowledged. The draft of the thesis was also approved by the advisory committee on .....

(Dr. G.C. Gahlot)
Head
Department of Animal Breeding & Genetics

(Dr. S.B.S. Yadav)
(Major Advisor)

(Dr. Tribhuwan Sharma)
Dean
College of Veterinary and Animal Science,
Bikaner

Rajasthan University of Veterinary and Animal Sciences

College of Veterinary and Animal Science

Bikaner – 334001

CERTIFICATE - III

Date…….....……

This is to certify that the thesis entitled **"Studies on Growth, Productive and Reproductive Performance of Sirohi Goats around Udaipur District of Rajasthan under Field Condition"** submitted by **Mr. Dudhe Shashank Deorao** to Rajasthan University of Veterinary and Animal Sciences, Bikaner, in partial fulfilment of the requirements for the degree of **Doctor of Philosophy** in the subject of **Animal Breeding and Genetics,** after recommendation by the external examiner, was defended by the candidate before the following members of the examination committee. The performance of the candidate in the oral examination on his thesis has been found satisfactory. We therefore, recommend that the thesis be approved.

(Dr. S.B.S. Yadav)
Major advisor

(Dr. R.K. Nagda)
Co-advisor

(Dr. Urmila Pannu)
Advisor

(Dr. S.C. Goswami)
Advisor

(Dr. S. K. Kashyap)
Advisor

(Dr. J. S. Mehta)
Dean, P.G.S. Nominee

(Dr. G.C. Gahlot)
Head
Department of Animal Breeding and Genetics

APPROVED

(Dr. G.S. Manohar)
DEAN
Post Graduate Studies,
RAJUVAS, Bikaner

Rajasthan University of Veterinary and Animal Sciences

College of Veterinary and Animal Science

Bikaner – 334001

CERTIFICATE – IV

Date……

This is to certify that **Mr. Dudhe Shashank Deorao,** of the **Department of Animal Breeding and Genetics,** College of Veterinary and Animal Science, Bikaner has made all corrections/modifications in the thesis entitled **"Studies on Growth, Productive and Reproductive Performance of Sirohi Goats around Udaipur District of Rajasthan under Field Condition"** which were suggested by the external examiner and the advisory committee in the oral examination held on…….....The final copies of the thesis duly bound and corrected were submitted on…..... are forwarded here with for approval.

(Dr. S.B.S. Yadav)
Major Advisor

(Dr. G.C. Gahlot)
Head
Department of Animal Breeding and Genetics,
College of Veterinary and Animal Science,
Bikaner

(Dr. Tribhuwan Sharma)
Dean
CVAS, Bikaner

Approved

(Dr. G.S. Manohar)
Dean
Post Graduate Studies
RAJUVAS, Bikaner

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Date: **DUDHE SHASHANK DEORAO**
Place: Bikaner

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