GENETIC ANALYSIS OF GROWTH FROM BIRTH TO 12 MONTH OF AGE IN JAMNAPARI GOATS

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By

Sanjeev Kumar

TO

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DEDICATED

TO

MY PARENTS

Dr. P.N. Bhat,
M.V.Sc., Ph.D. [Purdue]
Director.

Indian Veterinary Research Institute
Izatnagar, [UP] - 243122

CERTIFICATE

Certified that the research work embodied in this thesis entitled **"GENETIC ANALYSIS OF GROWTH FROM BIRTH TO 12 MONTHS OF AGE IN JAMNAPARI GOATS"** submitted by **Dr. Sanjeev Kumar** for the award of **Master's Degree** of Indian Veterinary Research Institute, is the original work carried out by the candidate himself under my supervision and guidance.

It is further certified that **Dr. Sanjeev Kumar** has worked for more than 24 months in the Institute (or at places recognised by the Institute) and has put in more than 150 days' attendance under me from the date of registration for the **Master's Degree** of University as required under the relevant ordinance.

[P.N. BHAT]
SUPERVISOR

CERTIFICATE

Certified that the thesis entitled **"GENETIC ANALYSIS OF GROWTH FROM BIRTH TO 12 MONTHS OF AGE IN JAMNAPARI GOATS"** submitted by **Dr. Sanjeev Kumar** in partial fulfilment of **M.V.Sc. Degree** of Indian Veterinary Research Institute, embodies the original work done by the candidate. The candidate has carried out his work sincerely and methodically.

We have carefully gone through the contents of the thesis and are fully satisfied with the work carried out by the candidate, which is being presented by him for the award of **M.V.Sc. Degree** of this Institute.

It is further certified that the candidate has completed all the prescribed requirements governing the award of **M.V.Sc. Degree** of Indian Veterinary Research Institute.

26/8/87

Signature of External Examiner

[P.N. BHAT]
CHAIRMAN

Members of Student's Advisory Committee

DR. V.K. TANEJA ______________________ 27.7.87

DR. RAJENDRA SINGH ______________________ 27.7.87

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Sanjeev Kumar

[SANJEEV KUMAR]

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INTRODUCTION

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INTRODUCTION

The goat, commonly referred to as "The Poorman's Cow" in India and "The Wet Nurse" in Europe, is a small ruminant of the order - Artiodactyla, suborder - Ruminantia and family - bovidae (hollow horned), and belongs to the genus Capra and species hircus (Asdell, 1946).

Archaeological evidences (Zeuner, 1963) show that goat was the earliest ruminant and probably the first animal after dog to be domesticated by man. There are still different schools of thought about the origin of domestic goats. Although origin of domestic goats has not been finally established on the basis of genetical studies so far, nevertheless, comparative morphological research and some information from breeding experiments suggest that wild Bezoar (C. aegagrus) of South-west Asia may be considered as the progenitor of domestic goats.

The goat empowered with the special qualities of adaptation to harsh environment, has the widest ecological and geographical distribution from extreme tropical rain forests to the driest deserts and from coldest uplands to hotest plains where other domestic animals cannot survive (Epstein, 1965). Goat manifests a high reproductive capacity and has been described to be highly disease tolerant (Horst, 1976).

Most goat populations are found in tropics, the reason being their small size, large surface area relative to body weight and limited subcutaneous fat cover which makes them relatively more adapted to the areas of high temperature than to cold climate (Shelton, 1978).

Goat is most appropriate for low stocking rates in areas where density of high quality forage is low (McDowell, 1986) and they can survive in heavy covered brouse areas where cattle can barely survive (Mackenzie, 1978 and McCammon-Feldman, et al., 1981).

There are around 460 million goats in the world, over 90% of them are distributed in the two continents, Asia and Africa (250 and 155 million, respectively). India possesses largest goat population, approximately 81 million, China, having 63 million is at second place (FAO, 1985).

Goats are useful for both milk and meat. It is the principal meat producing animal in India. They produce about 1230 thousand M tonnes of milk which is 3% of the total milk produced in India, besides they contribute about 1.54% of the total goat milk production in the world. Goats produce about 315 thousand M tonnes of meat which is 35.87% of the total meat produced in India from livestock except poultry. This quantity is 15.2% of the total goat meat produced in the world. Goats contribute about 3.74% of the total meat produced in the world from ruminants (FAO, 1985).

Goats have been recognised as the most effective livestock species for promoting the health and economy of poor people in the developing countries (Senger, 1980). The economic gain that goats offer to their owners have been assesed at a cost benefit ratio of 1:11.7 and an investment return rate (IRR) value of over 30% which is much more than any bank can give as interest (Senger, 1976).

According to Acharya et al. (1982) native goats are in general far more economical than native sheep and cattle. The superiority of goats is related to their higher reproduction rate, better digestive efficiency of cellulose and inquisite behaviour through their mouth parts which enables them to thrive even on scrub lands where other animals cannot.

Goat exhibits a high ratio of body weight to milk yield compared to other tropical milk animals. The nutrient input to produce 1 Kg. of milk is distinctly less in goat than in cattle and buffalo (Horst, 1976).

The nutritive value of goat milk is similar to that of cow's milk and it is believed to be more easily digestible than that of cow, buffalo or sheep. Unlike cows' milk, which is acidic in nature, goat milk is alkaline and therefore, recommended for infants and persons with hyperacidity (Prakash and Jenness, 1968 and Jenness, 1974).

Goat meat is more lean than mutton (Devendra, 1980). Higher protein and low calories in chevon as compared to mutton, pork, beef and poultry, make it of special interest to the people who are diet conscious (McDowell and Bove, 1977).

In India, goat husbandry has been accorded very low priority. The general belief that goats lead to desertification was responsible for this state. Goats have been shown to be beneficial to them under situations of degraded lands at the density of one animal along with its followers per acre (Acharya, et al., 1982). Indian planners have recently considered the contribution made by goats to the national income and their role in providing health and economic employment to the large number of small and marginal farmers and landless labourers including the urban poor. They have planned to improve native goats. A Central Institute for Research on Goats has been started at Makhdoom, Mathura (UP).

A recent World Bank study (1983) based on an analysis of 80 research projects on a regional basis concluded that there was a lack of support within developing countries and within international donor and lending agencies for research on goats. The report also found that little emphasis was given to research and training in developing countries. Inspite of the lack of the development programme for goats, in India, the population of goat has increased at the rate of one million (2%) per annum during past 25 years. Taneja (1979) attributed a high rate of reproduction, relatively higher resistance to disease and marketing facilities to be the factors for this increase.

Despite the fact that India possesses largest goat population and produces maximum meat in the world, this amount is far less than the need of Indian people. Since there is a continuous rise in the human population of India, there is a long standing gap between the requirement and production of goat meat. In order to cope with this demand, it is necessary to improve the performance of our indigenous breeds.

India has the largest diversity of breeds of goat. Owen (1975) reported that important meat producing breeds exist in the tropical Asia and far east as well as in Africa. Devendra (1980) suggested

Jamnapari as one of the important breeds for meat production in tropics. Since carcass characters are highly heritable than the fitness (reproductive) traits, there is considerable scope for use of Jamnapari breed which appears to be genetically superior with regards to carcass traits as an improver breed (Owen et al., 1978).

Jamnapari is one of the best dual purpose breeds of North - Western India, found in Etah District of Uttar Pradesh and ravines of Chambal and Jamuna rivers with a population size of 0.580 million and an average flock size of 16. Their home tract is spread around Agra, Mathura and Etawah District in Uttar Pradesh and Bhind and Morana in Madhya Pradesh. Jamnapari has been exported to a number of neighbouring countries for improvement of local stocks and has contributed to the development of famous Anglo-Nubian breed (Acharya, 1982; Acharya and Bhat, 1984 and Bhat et al., 1981).

Not much work has been done so far at selection combined with planned breeding to evolve selected strains of high potential for meat and milk from Jamnapari breed. Some biometrical studies in terms of body weight, body measurements, production and reproduction performance have been reported (Johri and Talpatra, 1971 and Singh, 1973). Therefore, it is important to intensify research on growth, production and reproductive performance of this breed.

Growth is the most important trait to meet the desired goal of milk, meat and fibre etc. A faster growth rate to produce more meat at an early age and cheaper cost can be achieved through selection, hence, while chalking out a breeding program it is extremely essential to study and establish the growth potential of this goat breed.

In the present study an attempt has been made to study growth in terms of body weight and body measurements from birth to 12 months of age and some biometrical correlations between body weight and body measurements in Jamnapari goats. The effects of various factors like year and month of birth, sex, type of birth and dam's weight at kidding on weight and measurements have also been studied.

Chapter - 2

geneticanalysisofgrowthfrombirthtotwelvemonthsofageinjamnaparigoats

REVIEW OF LITERATURE

geneticanalysisofgrowthfrombirthtotwelvemonthsofageinjamnaparigoats

REVIEW OF LITERATURE

Growth has been defined by many workers from time to time. Scholoss (1911) defined growth as a "Correlated increase in the mass of body in a definite interval of time in a way characteristic of the species", whereas, Brody (1945) defined growth as "a relatively irreversible time change in the measured dimensions" which indicated growth in terms of body weight as well as body measurements. Regardless of its definition, this is the most important single genetic trait on which a breeding plan has to depend.

BIRTH WEIGHT

Factors Affecting Birth Weight

Sire

Singh (1973) studied various genetic and non-genetic factors affecting birth weight of 315 Jamnapari kids sired by 4 bucks and maintained at State Sheep and Goat Farm, Orai, Jalaun (UP). Data were corrected for these effects and tested for the averages of birth weight by analysis of variance. The results revealed that sires had no significant effect on birth weight of their kids. A negative estimate of heritability was obtained, which was ascribed to sampling fluctuation.

Mavrogenis et al. (1984) studied genetic and environmental causes of variation in production traits of 1542 Damascus goats born during 1977-81. Environmental factors included season, type of birth, sex of kid, parity and interaction (type x sex). Sires within season were considered as random with mean zero and variance σ_s^2. Sires within a season had a significant effect on birth weight.

Year of birth

Guha et al. (1968) studied causes of variation in growth rate of 113 female and 121 male Black Bengal kids sired by 13 bucks.

They examined the effects of year, season of kidding, sex and type of birth on birth weight, weaning weight (16 weeks), market weight (36 weeks) and yearling weight (52 weeks). They reported that year of birth had a significant effect on birth weight.

Castillo et al. (1976) found that birth weight of Nubian, Alpine, Toggenburg and Saanen kids in Venezuala was significantly affected by year of birth.

Montaldo and Juarez (1980) studied factors affecting birth weight of 243 French-Alpine, 62 Anglo-Nubian, 98 Granada, 89 Saanen and 87 Toggenburg kids. They reported that year of birth had significant effect on birth weight.

Mohd-Yusuf et al. (1981) examined the effect of different non-genetic factors on birth weight of 16 Saanen x Katjang, 17 Anglo-Nubian x Katjang, 13 British-Alpine x Katjang and 42 Katjang kids. They reported that year of birth did not affect birth weight.

Darokhan and Tomar (1983) studied the effect of sex, year, age of dam on birth weight of 474 Changthang kids sired by 15 bucks and born during 1975 to 1979, maintained at Upshi, Leh (Ladakh). Least-squares analysis revealed that year of birth had a significant effect on birth weight.

Khan and Sahni (1983) studied pre-weaning body weights and linear body measurements of 111 Jamnapari kids born in March-April and September-November during 1976-78, maintained under semi-arid farm conditions and reported that year of birth did not affect birth weight.

Nagpal and Chawla (1984) examined the effect of various non-genetic factors on body weights from birth to 24 months of age on 135 male and 159 female Beetal and 111 male and 105 female Alpine kids born during 1972-82. They reported that year of birth had a significant effect on birth weight in both breeds.

Malik et al. (1986) studied the influence of various non-genetic factors such as year, season, type of birth, sex, and dam's weight at kidding on preweaning growth in Beetal and Black Bengal goats. The study involved 1174 kids born during 1979 to 1982. Year was considered as a fixed effect and found to have no significant effect on birth weight.

Type of Birth

Dutta et al. (1963) studied the birth weight of 42 Jamnapari kids and reported that birth weight of kids born as single, twin and triplet averaged 4.12±0.13 3.43±0.09 and 2.45±0.00 kg., respectively. They concluded that singles weighed more than twins and triplets at birth.

Guha et al. (1968) studied growth rate of 234 Black Bengal kids from birth to 1 year of age and reported that type of birth had a significant effect on birth weight and twins were heavier than singles.

Seth et al. (1968) studied factors affecting body weight of Barbari kids and reported that type of birth had no effect on birth weight.

Singh (1973) examined the effect of different factors on birth weight of 315 Jamnapari kids. He reported that birth weight averaged 4.54±0.05 and 4.17±0.05 kg. for singles and twins, respectively. Singles were heavier than twins.

Castillo et al. (1976) reported that type of birth had significant effect on birth weight of Nubian, Alpine, Toggenburg and Saanen kids.

Singh et al. (1977) reported that for 10 Saanen, 43 Barbari, 23 local, 9 1/2J 1/2S, 8 3/4S 1/4J, 6 1/2J 1/2L and 8 1/2B 1/2S goats, birth weight for singles and twins averaged 2.714±0.152 and nil (since there were no twin-born kids), 1.775±0.108 and 1.645±0.079 kg., 1.350±0.128 and 1.402±0.083 kg., 3.152±0.104 and 2.750±0.250 kg., 2.745±0.171 and 2.245±0.127 kg., 2.350±0.101 and 2.050±0.301 kg. and 1.868±0.142

and 2.142±0.207 kg., respectively for 7 breed groups. They observed that except in two type of crosses, viz. Barbari x Saanen and local x local, the average birth weight of kids born as single was higher than those born as twins. The averages were tested by t-test and found to be non-significantly different from each other.

Mittal and Pandey (1978) carrried out research on 62 Barbari kids born in spring season to study growth rate from birth to 9 months of age. Birth weight of singles averaged 1.95±0.29 and 1.98±0.18 kg. for male and female, respectively. Twins of similar sex averaged 1.74±0.20 and 1.82±0.17 kg. for males and females, respectively. Corresponding values for twins of dissimilar sex were 1.78±0.16 and 1.70±0.20 kg. Although twins had lower birth weight than singles, the difference was statistically non-significant.

Nath and Chawla (1978) studied birth weight of 147 Beetal, 87 Alpine, 152 Alpine x Beetal, 99 Saanen x Beetal and 53 Saanen x Alpine x Beetal kids maintained at NDRI, Karnal. They reported that male kids born as single had higher birth weight than twins and triplets in all breeds except Saanen x Alpine x Beetal cross where twins were heaviest. Similarly, single females were heavier than twins and triplets. Analysis of variance revealed that effect of type of birth on birth weight was statistically non-significant. This observation does not seem logical and can result only if the dams are badly managed during gestation.

Mittal (1979) studied birth weight and the factors affecting it on 140 Barbari and 46 Jamnapari kids. Author reported that although, singles were heavier than twins in both breeds the difference was statistically non-significant.

Montaldo and Juarez (1980) observed that type of birth had a significant effect on birth weight in 243 French-Alpine, 62 Anglo-Nubian, 98 Granada, 89 Saanen and 87 Toggenburg kids.

Mohd - Yusuf et al. (1981) reported that overall birth weight averaged 1.98 kg. for single born kids and 1.64 kg. for twin born kids in 16 Saanen x Katjang, 17 Anglo-Nubian x Katjang, 13 British-Alpine x Katjang and 42 Katjang kids. They further reported that singles were significantly heavier than twins ($P < 0.05$) indicating that type of birth had significant effect on birth weight.

Sarma et al. (1981) examined body weights from birth to 6 months of age, weight-gains and effects of type of birth and season of birth on above traits on 136 farm-born Assam local kids between May, 1977 and December, 1978 at Goat Breeding Research Station, Burnihat. They reported that birth weight averaged 1.29±0.05, 1.04±0.04 and 1.26±0.05 kg. for singles, twins and triplet, respectively. Singles were heaviest. Analysis of variance revealed that type of birth had significant effect on birth weight.

Khan and Sahni (1983) analysed the data on birth weight of 111 Jamnapari kids and found that type of birth had a significant effect on birth weight.

Ozekin and Akcapinar (1983) reported that birth weight averaged 2.5 kg. for singles and 2.4 kg. for twins in Angora goat. Analysis of data revealed that type of birth had a significant effect on birth weight and singles were heavier than twins.

Prasad (1983) reported that single born kids from nulliparous females were even lighter than twin born kids from mature multiparous females at birth.

Singh et al. (1983a) studied growth of 89 male and 99 female Black Bengal and 90 male and 59 female crossbreds and examined different factors affecting growth. They reported that type of birth had a significant effect on birth weight.

Mavrogenis et al. (1984) examined the influence of various factors on birth weight of 154 Damascus kids. Least-squares analysis (Harvey, 1975) was used for this purpose. It revealed that type of birth had a significant effect on birth weight. Singles were heavier than twins or other multiples at birth ($P<0.01$) in Damascus goat.

Sarma et al. (1984) studied body weights and body measurements of 61 Assam local x Beetal kids of preweaning age maintained at Assam Agric. Univ. station at Burnihat. They examined various factors affecting birth weight. They reported that it averaged 1.51±0.07 kg. for singles and 1.30±0.04 kg. for twin born kids. Type of birth had significant effect on birth weight. Singles were heavier than twin born kids ($P<0.05$).

Baik et al. (1985) examined the effect of various factors on preweaning growth on 157 Korean native kids and reported that type of birth had significant effect on birth weight.

Malik et al. (1986) analysed the data by least-squares method of fitting constants, on birth weight of 1174 kids (Beetal, Black Bengal and their crosses). They reported that effect of type of birth on birth weight was highly significant ($P<0.01$). The kids born as single had a higher birth weight (2.10 kg.) than those born either as twins (1.76 kg.) or as triplets (1.35 kg.).

Sex of Kid

Dutta et al. (1963) reported that birth weight for male and females averaged 3.59±0.38 and 3.62±0.46 kg., respectively. They concluded that sex of kid had no influence on birth weight in Jamnapari goat.

Seth et al. (1968) reported that birth weight of male kid was higher than female kid in Barbari goat and concluded that sex had a significant influence on birth weight.

Prasad et al. (1971) studied live weight gains in Barbari kids from birth to 1 year of age and found that male kids were significantly heavier than female kids for both single and multiple births.

Singh (1973) studied birth weight of 315 Jamnapari kids and reported that birth weight for male and female averaged 4.92±0.08 and 4.25±0.06 kg. for single born kids and 4.46±0.08 and 3.96±0.06 kg. for twin-born kids, respectively. He concluded that males were heavier than females ($P < 0.01$).

Singh (1975) on the basis of his study on birth wieght of 511 kids belonging to Angora and Gaddi crosses reported that sex had a significant effect on birth weight of kids.

Castillo et al. (1976) reported that sex had a significant influence on birth weight of Nubian, Alpine, Toggenburg and Saanen kids.

Singh et al. (1977) recorded the birth weight of 10 Saanen, 42 Barbari, 23 local, 9 1/2J 1/2S, 8 3/4S 1/4J, 6 1/2J 1/2L and 8 1/2B 1/2S kids. They employed t-test to ascertain the effect of sex on birth weight and reported that in all groups males were heavier than females which they attributed to the hereditory factors.

Mittal and Pandey (1978) studied growth rate on 62 Barbari kids. They reported that there was no significant difference in birth weights of male and female kids born as either single or twin.

Nath and Chawla (1978) studied birth weight of 538 kids (Beetal, Alpine and their crosses). They reported that effect of sex on birth weight was highly significant ($P < 0.01$) and male kids of all breeds and those of crosses registered higher birth weight than females.

Mittal (1979) studied birth weight of 140 Barbari and 46 Jamnapari kids. They noticed a significant effect of sex on birth weight ($P < 0.05$) in both the breeds. Males were heavier than females. He explained this to be due to male sex hormone secreted by gonads, which has an anabolic effect (Hafez, 1962), therefore males grew faster during prenatal development.

Ali (1980) studied the relationship of birth weight with post-natal growth in 162 Black Bengal kids maintained at Bangladesh Agricultural University and reported that birth weight of Black Bengal for 77 male and 90 female kids averaged 1.80±0.08 and 1.75±0.06 lb., respectively. Apparently there was a difference in birth weights of male and female kids but it was not statistically significant. Therefore, he concluded that sex had no influence on birth weight of Black Bengal kids.

Montaldo and Juarez (1980) reported birth weight of male and female kids as 3.42 kg. VS 3.10 kg. for 243 French-Alpine, 62 Anglo-Nubian, 98 Granada, 89 Saanen and 67 Toggenburg kids. They reported that sex had a significant effect on birth weight.

Cyprus, Agricultural Research Institute, annual report (1981) detailed the birth weight for 1542 Damascus kids. The male and female kids averaged 4.7 and 4.2 kg., respectively. It was concluded that males were significantly heavier than females at birth.

Mohd-Yusuf et al. (1981) did not find a significant difference between male and female kids for birth weight in 16 Saanen x Katjang, 17 Anglo-Nubian x Katjang, 13 British Alpine x Katjang and 42 Katjang kids.

Darokhan and Tomar (1983) studied birth weight of 474 Changthang kids and reported that sex had a highly significant effect on birth weight. Male kids were heavier than the female kids and this could be due to the effect of male sex hormones, which has anabolic effect (Hafez, 1962) and thus male foetus grew faster during prenatal development.

Khan and Sahni (1983) studied birth weight of 111 Jamnapari kids and reported that birth weight was significantly affected by sex of the kid.

Ozekin and Akcapinar (1983) reported that for 153 Angora kids, birth weight averaged 2.6 kg. for males and 2.4 kg. for females, the difference being significant.

Singh et al. (1983a) studied the growth rate of 198 Black Bengal and 149 1/2 Jamnapari 1/2 Black Bengal kids and reported that birth weight for male and female in 2 breed groups averaged 1.3 and 1.2 kg., and 1.4 and 1.4 kg., respectively. They reported that sex had a significant effect on birth weight.

Singh et al. (1983b) examined the effect of various factors affecting birth weight and weaning weight on the kids born during 1966-69 and reported that birth weight in Jamnapari and Barbari kids was significantly affected by sex of the kid.

Chawla et al. (1984) employed least-squares technique to study the effect of sex on body weight at birth on 294 Beetal, 216 Alpine and 42 Saanen kids born during 1972-1982, reared in confined housing and were mostly weaned at birth. They reported that sex had a significant effect on birth weight in all the three breeds and males registered higher body weight than females at birth.

Mavrogenis et al. (1984) studied the influence of sex of kid on birth weight of 1542 Damascus kids, along with other non-genetic factors such as type of birth, season etc. Least-squares technique revealed that sex of kid had highly significant effect on birth weight of kids ($P<0.01$). Male kids were heavier than female kids.

Misra and Rawat (1984) analysed the data on birth weight of 242 Sirohi kids by weighted analysis of variance to examine the effect of season of kidding, sex of kid and their interaction on weight and configuration. They showed that sex had highly significant effect on birth weight ($P<0.01$) and males were significantly superior to females with respect to body weight and all body measurements at birth.

Nagpal and Chawla (1984) reported that sex had a significant effect on birth weight of 294 Beetal and 216 Alpine kids.

Sarma et al. (1984) studied the effect of various factors on birth weight and showed that sex did not influence birth weight of 61 farm-bred Assam local x Beetal kids.

Baik et al. (1985) reported sex to be an important source of variation for birth weight of 157 Korean native goats.

Naik et al. (1985) studied some factors affecting body weights at different ages in Ganjam goats. They reported that sex had a significant effect on birth weight of 418 Ganjam kids.

Malik et al. (1986) analysed the data on birth weight of 1174 kids from Beetal, Black Bengal and their crosses by the least-squares method of fitting constants. They showed that sex had highly significant effect on birth weight ($P < 0.01$) and male kids (1.82 kg.) were significantly heavier than female kids (1.66 kg.).

Season/Month of Birth

Prasad et al. (1971) reported that season had no influence on the birth weight of Barbari kids.

Singh (1973) studied the effect of season on birth weight of 315 Jamnapari kids. The classification of season was : Summer (March to June), Rainy (July to October) and Winter (November to February). Results revealed that season of kidding had no influence on the birth weight of kids.

Castillo et al. (1976) reported that month of kidding had significant effect on the birth weight of Nubian, Alpine, Toggenburg and Saanen kids.

Singh et al. (1977) studied birth weight of pure and crossbred kids. Year was divided into three seasons, viz. winter (November to February), Summer (March to June) and rainy (July to October), to study the effect of season on birth weight of kids. Analysis of variance (Snedecor and Cochran, 1968) was used for the above purpose. Authors reported that summer as kidding season was inferior to winter and rainy seasons. Poor nutritional level due to inadequate grazing and physiological stress resulting from heat and allied environmental conditions might be accounted for it. Effect of season of birth on birth weight was significant in Barbari but not in local goats. This could be due to acclimatization of local goat to the existing climatic conditions. Barbari stock used in the study was brought here only a few years back and it might not have adjusted to the changed climate.

Mittal (1979) studied birth weight of 140 Barbari and 46 Jamnapari kids. These kids were born in summer (April-May) and winter (December-January). Analysis of data revealed that season had highly significant effect on birth weight of kids. The winter-born kids were significantly superior to the summer-born kids ($P < 0.01$) in birth weight. Author reported that winter was superior to summer as kidding season. Poor nutrition accompanied by inadequate grazing and physiological stress caused by excessive heat and other similar conditions was responsible for this effect.

Reynold (1979) reported that month of birth had no significant effect on birth weight of 37 Malawi kids born in August and December.

Montaldo and Juarez (1980) reported that season of kidding had no significant influence on the birth weight of French-Alpine, Anglo-Nubian, Granada, Saanen and Toggenburg kids.

Sarma et al. (1981) studied the effect of seasons on birth weight. They used birth weight records of 84 kids born in season 1 (October-March) and 52 kids born in season 2 (April-September) of Assam local breed. They reported that season of birth had non-significant effect on birth weight though kids born in October-March (1.23 ± 0.04 kg.) were heavier than kids born in April-September (1.09 ± 0.05 kg.), this difference might be due to the scarcity of greens during the gestation period of dams giving birth in season 2.

Khan and Sahni (1983) analysed data on 111 Jamnapari kids born in March-April and September-November during 1976-78 for birth weight. They did not find any significant effect of season on birth weight in Jamnapari goat.

Singh et al. (1983b) analysed data on birth weight of Jamnapari and Barbari kids by least-squares analysis and reported that season had a significant effect on birth weight.

Mavrogenis et al. (1984) studied birth weight of 1542 Damascus kids born in 4 successive seasons (1977/78, 1978/79, 1979/80 and 1980/81). Statistical analysis using least-squares procedure revealed that season of kidding had a significant effect on birth weight.

Misra and Rawat (1984) analysed data on birth weight of 242 Sirohi kids born during 1977-78. The kidding took place in three seasons viz. spring (February-March), mansoon (July-August) and autumn (October-November). Authors reported that birth weight was significantly affected by the season of kidding. Effect of season on birth weight is largly an environmental factor and is influenced by the intrauterine environmental conditions during the prenatal life. Spring born kids were having lower body weight at birth as compared to mansoon and autumn born kids because their dams were under nutritional and environmental stress.

Nagpal and Chawla (1984) reported that season had a significant effect on birth weight of Beetal and Alpine kids.

Baik et al. (1985) reported that season of birth had a significant effect on birth weight of Korean native kids. Kids born in spring or summer were heavier than those born in autumn or winter.

Naik et al. (1985) analysed data on birth weight of 418 Ganjam kids and found that season of birth had a significant effect on body weight at birth.

Malik et al. (1986) analysed the data on birth weight of 1174 kids (Beetal, Black Bengal and their crosses) by the technique of least-squares analysis. The two seasons of kidding observed were February to April and September to November. They reported that season of birth had a highly significant effect ($P < 0.01$) on birth weight and the kids born during February to April had a higher birth weight (1.85

kg.) than those born during September to November (1.63 kg.) The variation in birth weight of kids in two seasons could be reflexion of the availability of pasture to their dams.

Type of Birth x Sex of kid

Barbieri et al. (1983) investigated some productive and reproductive characteristics of 300 crossbred goats in the Matera area under field conditions. They reported that sex difference was significant for twins and the effect of type of birth was highly significant for female kids with regards to birth weight.

Singh et al. (1983a) reported that interaction between type of birth and sex was significant for birth weight of 188 Black Bengal and 149 1/2 Jamnapari 1/2Black Bengal kids.

Mavrogenis et al. (1984) revealed that interaction of type of birth with sex of kid had no influence on birth weight of 1542 Damascus kids.

Nagpal and Chawla (1984) reported that sex within litter size had a significant effect on birth weight of Beetal and Alpine kids.

Sarma et al. (1984) reported that interaction (type of birth x sex) had no significant effect on birth weight of 61 farm-born Assam local x Beetal kids.

Weight of Dam at Kidding

Prasad et al. (1971) reported that weight of dam at kidding had a significant effect on birth weight in Barbari goats.

Ayoadae and Butterworth (1982) studied birth weight and weaning weight of 107 Boer, 38 Malawi and 39 Boer x Malawi kids and reported that dam's weight at parturition had no significant effect on birth weight in either of the groups.

Khan and Sahni (1983) reported that dam's weight at kidding had significant effect on birth weight of Jamnapari kids.

Singh et al. (1983b) reported that weight of dam had no significant effect on birth weight of Jamnapari and Barbari kids.

Malik et al. (1986) analysed the data by least-squares technique considering weight of dam at kidding as covariate. They reported that dam's weight at kidding had highly significant effect on birth weight of kids in Beetal, Black Bengal goats and their crosses.

Correlation Between Birth Weight and Dam's Weight at Kidding

Mittal (1979) analysed data on birth weight of 140 Barbari and 46 Jamnapari kids and their dam's weight at the kidding and calculated correlation coefficient between birth weight and post kidding weight of their dams. Author reported that 'r' values for male and female kids were 0.914 and 0.699 in case of single born and 0.697 and 0.926 in case of twin born kids, respectively, in Barbari kids. Corresponding 'r' values in Jamnapari kids were 0.998 and 0.879, and 0.917 and 0.714^{NS}. Author concluded that there existed a close assciation between dam's weight at kidding and birth weight of kids.

Mohd-Yusuf et al. (1981) reported a significant correlation (r=0.4) between dam's weight at kidding and birth weight in 16 Saanen x Katjang, 17 Anglo-Nubian x Katjang, 13 British Alpine x Katjang and 42 Katjang kids.

Heritability of Birth Weight

Guha et al. (1968) calculated heritability of birth weight by regression of progenies' weight on dam's weight after kidding. They reported h^2 of birth weight as 0.067 in Black Bengal goats.

Castillo et al. (1976) reported heritability of birth weight as 0 (zero) in Nubian, Alpine, Toggenburg and Saanen goats.

Montaldo and Juarez (1980) estimated heritability of birth weight as 0.56±0.17 in French Alpine, Anglo-Nubian, Granada, Saanen and Toggenburg goats.

Ali (1983) estimated heritability of birth weight from the data on 324 Black Bengal kids sired by 9 bucks and maintained at Bangladesh Agricultural University, Mymensingh by the method described by Becker (1964). They reported that family heritability of birth weight in Black Bengal goats, was 0.398±0.239 and it may respond favourably to individual selection.

Darokhan and Tomar (1983) estimated heritability by Paternal Half-sib Correlation method (Hazel and Terril, 1946) and pooled heritability according to Dettmers (1962). The standard error of heritability was calculated according to Dickerson (1959) for birth weight. Heritability of birth weight was 0.06±0.01 for male, 0.04±0.1 for female and pooled h^2 was 0.05±0.08. The low heritability indicated no measurable additive genetic variance, hence, no mass selection could be practiced to improve the birth weight of kids.

Madeli and Patro (1984) estimated heritability by Paternal Half-sib Correlation method. The data used in the study was on 342 Ganjam kids born as progeny of 28 sires and 216 dams. They reported heritability of birth weight as 0.18±0.14. Low heritability estimate indicated that additive genetic variability at birth was less. Birth weight being highly influenced by maternal effect, a low heritability was quite expected.

Mavrogenis et al. (1984) analysed data on 1542 Damascus kids and estimated heritability of birth weight by Paternal Half-sib Correlation method and reported it as 0.31±0.08.

Correlation Between Birth Weight and Subsequent Growth/Body Weight

Dutta et al. (1963) determined the correlation between birth weight and live weight at 1 month in Jamnapari goat. The correlation coefficient (r=0.7) showed a high degree of correlation between birth weight and live weight gain during the first month.

Montemurro (1966) studied growth of crossbred Maltese goats from birth to 40 days of age. He determined the correlation coefficient between birth weight and 30 day weight. It was 0.83 indicating that there existed a close association between birth weight and 1 month weight. Guha et al. (1968) reported that birth weight had a significantly fair correlation with yearling weight in Black Bengal goat. Wijeratne (1968) reported a correlation coefficinet 0.57±0.16 between birth weight and 1 year weight in south Indian goat.

Ali (1980) worked out the product moment simple phenotypic correlation coefficients between birth weight and weight at 1, 4, 8 and 13 week of age in Black Bengal goats. They were 0.709, 0.401, 0.479 and 0.150^{NS}, respectively in case of male. Coresponding values in female were 0.573, 0.259, 0.399 and 0.259^{NS}. It was found that the correlation coefficients between birth weight and first week weight and those at 4th and 8th week were highly significant in both sexes. This indicated that effect of birth weight on subsequent live-weights of kids was significant upto 8th week of their lives in both sexes.

Mohd-Yusuf et al. (1981) reported that birth weight was significantly correlated with preweaning average daily gain (r=0.63) and 90 days weight (r=0.52) in 16 Saanen x Katjang, 17 Anglo-Nubian x Katjang, 13 British Alpine x Katjang and 42 Katjang kids.

Ayoadae and Butterworth (1982) reported that their existed a significant correlation between birth weight and weaning weight in Malawi goats (r=0.48) and Boer x Malawi goats (r=0.47).

Madeli and Patro (1984) calculated the genetic, phenotypic and environmental correlations between birth weight and body weights at 6, 12, 18 and 24 month of age in Ganjam goats according to Falconer (1960). They reported that phenotypic correlations between birth weight and 6, 12, 18 and 24 month weight were 0.334±0.065, 0.028±0.076, 0.005±0.090 and 0.091±0.096 respectively. Corresponding genetic correlations were 0.920±0.078, -0.351±0.458, -0.387±0.414 and -0.315±0.550. Similarly, the environmental correlations were 0.141, 0.63, 0.261 and -0.019 for 6, 12, 18 and 24 months respectively. Authors reported that phenotypic correlation coefficients between birth weight and weights at 12 months and above ages were very low and insignificant. So, it may be concluded that birth weight had no relationship with weights at 12 month and subsequent ages. The genetic correlation between body weight at birth and 6 months was very high and positive which indicated similar genetic influence was prevailing in both the ages. The phenotypic correlation was however, medium due to low environmental correlation. The genetic correlation between birth weight and weight at 12, 18 and 24 months of age were negative which meant that kids having high body weight at birth genetically, happened to attain low weight at 12, 18 and 24 months of age and vice-versa. Environmental correlations were also low indicating that the environmental influences at birth and at other ages were not similar.

Mavrogenis et al. (1984) estimated phenotypic and genetic correlation between birth weight and weaning weight, 140-day weight and post-weaning growth rate in Damascus kids. The data on 1542 kids sired by 85 bucks were used for the estimation of genetic parameters. They reported that phenotypic correlation between birth weight and weaning weight, 140-day weight and post-weaning growth rate were 0.43, 0.37 and 0.19, respectively. Corresponding genetic correlations were 0.34±0.17, 0.41±0.17 and 0.28±0.19. They concluded that birth weight was poorly correlated genetically with all other traits studied. Phenotypic correlations were moderate indicating that birth weight was not an important criterion to select for higher body weight at subsequent ages.

Misra and Rawat (1984) reported that birth weight had highly significant correlation (r=0.6823) with weaning weight ($P<0.01$) in Sirohi kids and birth weight can be used as a basis of selection for improving weaning weight.

Malik et al. (1986) studied factors affecting preweaning growth in Beetal, Black Bengal goats and their crosses. They also calculated phenotypic correlations between birth weight and other preweaning growth traits. They reported that phenotypic correlation between birth weight and 1, 2, 3 month weight and preweaning gain (gm/day) in Beetal goats were 0.33±0.07, 0.23±0.08, 0.17^{NS}±0.02 and -0.03^{NS}± 0.00 respectively. Corresponding values in case of Black Bengal goats were 0.43±0.05, 0.41±0.05, 0.25±0.06 and 0.04±0.06, respectively. Authors concluded that birth weight was mostly correlated positively and significantly with preweaning growth traits.

BODY WEIGHT AND MEASUREMENTS

Factors Affecting Body Weight and Measurements

Sire

Mukundan et al. (1983) examined the effect of various factors on preweaning body weights on 140 Malabar and 177 Saanen x Malabar kids born during 1974-77. They reported that sire had significant effect on weaning weight of Malabar goats.

Mavrogenis et al. (1984) reported that sires within season had significant effect on weaning and 140-day weights of Damascus goats.

Year of Birth

Guha et al. (1968) examined the effect of various factors on body weights at different ages in Black Bengal kids born during 1956-61. The data were analysed by t-test. They reported that weight-gain from birth to 52 weeks was significantly affected by year of birth.

Mohd-Yusuf et al. (1981) reported that year of birth had a significant effect on weaning weight in crossbreds.

Darokhan and Tomar (1983) reported that year of birth had significant effect on birth weight and heart girth and height at withers at birth ($P < 0.01$) in Changthang kids.

Khan and Sahni (1983) examined the effect of various factors affecting body weights and body measurements at birth, 1 month, 2 month and weaning (3 month) on 111 Jamnapari kids born during 1976-78. They reported that year of birth had a significant effect on body weight at 1 and 2 months of age.

Mavrogenis (1983) examined the effect of year of birth along with other factors (month and type of birth, sex, sex x type etc.) on 1542 Damascus kids born in four successive years (1977-1981) on weaning weight, 140 day weight and pre-and post-weaning growth rates. Author reported that year of birth had significant effect on weaning and 140-day weight and so also the pre-and post-weaning growth rates, which they attributed to dissimilar sanitary conditions, some changes in feed texture (pelleted or mash concentrate feed etc.) as well as body condition of the dam.

Mukundan et al. (1983) determined the effect of year of birth on body weights at 1, 2 and 3 months of age and reported that year had significant effect on body weight at all ages.

Nagpal and Chawla (1984) investigated the effect of year of birth on body weights from birth to 24 months at 3 month interval on 294 Beetal and 216 Alpine kids born during 1972-1982. They reported that year of birth had significant effect on body weights at different ages.

Nagpal and Chawla (1985) examined the effect of year of birth on body weights from birth to 24 months on 1,641 crossbred kids born during 1972-1974 and reported it to be significant on weight at birth and at varying ages in all the crossbreds except at 6 months in Alpine x Saanen x Beetal. They attributed it to the differences in genetic constitution and managemental practices.

Malik et al. (1986) studied the effect of various factors on pre-weaning growth traits on 1175 kids born during 1979-1982 in Beetal, Black Bengal goats and their crosses. The year effect was determined by least squares method (Harvey, 1966) taking it as a fixed effect and found to have significant effect on 1, 2 and 3 month weight ($P < 0.01$) but not on birth weight.

Type of Birth

Guha et al. (1968) reported that type of birth had no influence on body weights of Black Bengal goats at different ages except on birth weight of male kids.

Seth et al. (1968) analysed data on body weights at birth, 1, 2 and 3 months of age in Barbari goats. They reported that male born as partner to female was significantly heavier than its female counterpart at birth and so also the twin born male to twin born female. At 1 month, significant difference was found in the weights of males and females born as single; males born as partner to females were significantly heavier than their female counterpart. No significant difference could be found in the weights of twin males and females.

Prasad et al. (1971) reported that live weight gain from birth to 1 year of age was not affected by type of birth in Barbari goat.

Castillo et al. (1976) reported that yearling weight was not affected by type of birth in Nubian, Alpine, Toggenburg and Saanen goats.

Reynold (1979) studied the effect of type of birth on body weights at 12 weeks and 24 weeks of age and reported that single born kids had greater ($P < 0.01$) average live weight at 12 weeks of age (9.0 ± 1 and 8.9 ± 2 kg. for male and female, respectively) than kids from multiple births (6.6 ± 0.6 and 5.4 ± 1.4 kg.). It has no effect on body weight at 24 weeks of age.

Mohd-Yusuf et al. (1981) reported that at weaning (90 day) singles (7.93 kg.) were significantly heavier ($P < 0.05$) than twins (5.08 kg.).

Sarma et al. (1981) studied the influence of type of birth, season of birth and their interaction on body weights at different ages in Assam local goats. They reported that kids born as singles had higher body weights than twins and triplets. The difference in body weight between singles and twins increased gradually upto 135th day, but between singles and triplets it narrowed down after 90th day. Triplets were heavier than twins. The kids with higher birth weight continued to be heavier at later stages of growth. The reason for singles to be heavier, given was that the dams with more than one kid could not provide sufficient pre-and post-natal care to individual kids. This difference can be reduced if extra milk is bottle-fed to kids born as twins or triplets.

Khan and Sahni (1983) examined the effects of various factors on body weight and body measurements in preweaning period. They reported that type of birth had significant effect on body weight at birth, 1, 2 and 3 months and so also on body measurements (chest girth, withers' height and paunch girth).

Mavrogenis (1983) reported that type of birth had a significant effect on weaning weight and 140-day weight in Damascus goats. Since preweaning growth and weaning weight are a function of individual potential for growth, maternal effects (through milk and other maternal genetic and environmental factors) and/or carry over effects of live weight at birth, litter size born and number of individuals sucking, these are likely to be affected by type of birth. Singles were heavier than twins and triplets at birth, weaning and 140 days of age.

Mukundan et al. (1983) reported that type of birth had significant effect on 1 month weight but non-significant effect on weights at 2 and 3 months of age in Malabar and Saanen x Malabar goats.

Ozekin and Akcapinar (1983) examined the effects of various factors on birth weight, weaning weight, 6 month and 1 year weight on 153 Angora kids and reported that type of birth had significant effect on birth and weaning weights and no significant effect on 6 month weight.

Singh et al. (1983a) investigated the influence of various factors on body weights at birth, weaning (12 weeks), 24, 36 and 48 weeks of age in Black Bengal and 1/2 Jamnapari 1/2 Black Bengal goats. They reported that type of birth had a significant effect on body weights at almost all ages.

Mavrogenis et al. (1984) reported that in Damascus goats, single born kids were significantly heavier at birth, weaning and 140 days of age than the kids in multiple births ($P<0.01$). Type of birth did not affect the post weaning growth rate, the reason may be that the differences in early perinatal growth (until weaning) are caused, to a considerable extent, by maternal factors, such as the size of litter (reflected in individual birth weights), the availability of milk, the number of suckings, and their vitality and aggressiveness.

Sarma et al. (1984) studied the effects of type of birth, sex and their interaction on body weights and body measurements (body length, height at withers and chest girth) of 61 Assam local x Beetal kids in preweaning period. They reported that type of birth had a significant effect on body weight at birth and 45 days, and on body measurements at 45 and 90 days. Singles were heavier than twins, the reason may be that the does with more than one kid could not provide sufficient pre-and post-natal care to individual kids. Singles showed significantly larger ($P<0.01$) measurements (except at birth) than those born as twins. They attributed it to the fact that single born kids could get more amount of milk from their dams and grew faster than those born as twins.

Baik et al. (1985) reported that type of birth had a significant effect on body wieghts and body measurements through out the pre-weaning period in Korean native goats.

Malik et al. (1986) examined the effects of various factors on pre-weaning growth of Beetal, Black Bengal kids and their crosses. They reported that type of birth had a siginficant effect on all body weights in pre-weaning stage. The kids born as single had a higher mean birth weight than those born in multiple births. This trend was maintained until weaning (3 month).

Sex of Kid

Guha *et al.* (1968) reported that gain in body weight from birth to 52 weeks of age in Black Bengal goat was significantly influenced by sex of the kid.

Seth *et al.* (1968) reported that sex had a significant effect on birth weight and 1 month weight of Barbari kids but not on 2 and 3 months weight.

Johri and Talpatra (1971) did not find any significant difference in the growth rate of male and female Jamnapari kids from birth to 15 weeks of age, though males were heavier than females at birth.

Castillo *et al.* (1976) reported that sex had a significant effect on birth weight and yearling weight in Nubian, Alpine, Toggenburg and Saanen goats.

Mittal and Pandey (1978) reported that although statistically non-significant, male kids were heavier than female at each stage of growth from 1 to 9 month of age in Barbari goats. This effect might be due to sex hormone secreted by gonads which has an anabolic effect (Hafez, 1962), thus male kids under the influence of male sex hormone grew faster during pre- and post-natal development periods.

Mohd-Yusuf *et al.* (1981) reported that sex had significant effect on preweaning average daily gain and 90-day weight (weaning weight) in Katjang and crossbred goats.

Darokhan and Tomar (1983) examined the effect of sex of kid on body weight and body measurements (body length, heart girth and height at withers) on 474 Changthang kids. They reported that it had significant effect on all 4 traits. Males were heavier and having larger dimensions than females. This might be due to their fast prenatal development because of the male sex hormone, which has an anabolic effect (Hafez, 1962).

Khan and Sahni (1983) analysed data on body weights and body measurements at birth, 1, 2 and 3 months of age on 111 Jamnapari kids and reported that sex had significant effect on birth weight, chest girth, paunch girth and chest width at birth, paunch girth at 1 and 3 months and withers' height and chest width at 3 months.

Mukandan et al. (1983) reported that sex had significant effect on body weights at 1, 2 and 3 months of age in Malabar and Malabar x Saanen goats.

Ozekin and Akcapinar (1983) reported that sex had significant effect on birth, 3, 6 and 12 months weight in Angora goat.

Singh et al. (1983a) examined the effect of sex on body weights at birth, 12, 24, 36 and 48 weeks of age and reported that sex had significant effect upto 24 weeks of age.

Mavrogenis et al. (1984) examined the effects of various factors on birth weight, weaning and 140-day weights and pre-and post-weaning growth rates of Damascus goats. They reported that male kids were always heavier ($P<0.01$) and grew faster ($P<0.01$) than female kids.

Misra and Rawat (1984) studied the effect of sex on body weight and body measurements (body length, heart girth, paunch girth and height at withers) at birth and weaning in Sirohi goat. They reported that sex had significant effect on all traits at birth but only on heart girth at weaning.

Nagpal and Chawla (1984) examined the effects of various factors on body weights at birth and at 3 months interval upto 24 months of age for Beetal and Alpine goats. They reported that male kids registered higher ($P<0.05$) body weights than female at birth and at different chronological ages in Beetal and Alpine except at 6 months in Beetal and 3 and 6 months in Alpine, where the difference was non-significant.

Sarma et al. (1984) studied the effects of various factors on body weight and body measurements (body length, height at withers and heart girth) at birth, 45 and 90 days of age on 61 Assam local x Beetal kids. They reported that though the male kids were heavier than female but it was not statistically significant in all age groups. The male kids were significantly superior to the female ones with regard to their body conformation only at birth. These findings revealed that after birth, both the male and the female kids achieved equal body conformation.

Nagpal and Chawla (1985) reported that males were heavier ($P < 0.05$) than females in most of the crosses involving Alpine, Saanen and Beetal at different ages.

Naik et al. (1985) examined the effect of sex on 418 Ganjam goats and reported that sex had significant effect on body weight at birth but not on weights at 6, 12, 18 and 24 months of age.

Nicoll (1985) reported that males were heavier at weaning than females ($P < 0.001$) in Angora goats.

Malik et al. (1986) conducted research to study the effects of various factors on body weights at birth, 1, 2 and 3 months of age in Beetal, Black Bengal goats and their crosses. They reported that males were heavier ($P < 0.01$) than females at all ages.

Month/Season of Birth

Guha et al. (1968) on the basis of t-test, reported that season of birth had significant effect on the body weight gain from birth to 52 weeks of age in Black Bengal goats.

Reynold (1979) reported that month of birth had no significant effect on birth weight or on live weight at 12 and 24 weeks of age in Malawi goats.

Sarma et al. (1981) studied the growth of 136 Assam hill kids born in October-March and April-September. They reported that the season of birth had no significant effect on body weight at birth, 45 and 180 days of age but had significant influence on 90-and 135-day weights. The kids born in October-March were heavier than those born in April-September; this difference increased upto 90th day of age after which it declined. The lower body weights of kids born during April-September might be due to scarcity of greens during the gestation period of dams and when the kids were weaned.

Khan and Sahni (1983) examined the effects of various factors on body weights and body measurements at birth, 1, 2 and 3 months of age on 111 Jamnapari kids born during March-April or September-November. They reported that season of birth had a significant effect on body weight and most body measurements at 2 and 3 months of age.

Mavrogenis (1983) reported that month of birth had a significant effect on growth i.e. weaning weight, 140 day weight and pre-and post-weaning growth rate in Damascus goats. Kids born between October and February were heavier than those born in March and April. The reason might be that the latter were weaned in the summer.

Mukundan et al. (1983) studied Malabar and Malabar x Saanen kids and reported that month of birth had significant effect on 2 month weight but not on 1 and 3 month weight.

Misra and Rawat (1984) studied the effects of various factors on body weight and body conformation at birth and at weaning in Sirohi goat. They observed that the body weight and measurements at birth were significantly affected by season of kidding, whereas seasonal differences were significant only for length and paunch girth at weaning. The kids born in mansoon (July-August) and autumn (October-November) were superior to the kids born in spring (February-March) season. They attributed it to the reason that the spring season is lean period for goats in semi-arid regions of Rajasthan and does in advance pregnancy were not provided with concentrate suppliments to counter balance nutritional stress, resulting into poor bodyweight of the kids. Since body weight and measurements are highly correlated, this influenced the configurational traits also. The non-significant effect of month of birth on weaning weight may be due to the reason that kids could be able to compensate subsequently because of adequate pasture availability. However, the difference in length persisted because body length has a relatively slower growth as compared to other configurational traits (Wilson, 1958).

Mavrogenis et al. (1984) reported that season of birth had significant effect on birth weight, weaning weight, 140 day weight and pre- and post-weaning growth rates. This might be due to the reason that food differed in different seasons.

Nagpal and Chawla (1984) studied the effects of various factors on body weights from birth to 12 months of age in Alpine and Beetal goats born in Winter (November-January), spring (February-April), summer (May-July) and Autumn (August-October). They reported that Beetal kids born in winter were heavier ($P < 0.05$) than those born in autumn, whereas, Alpine kids born in autumn were heavier than those born in summer and winter. The influence of season was more pronounced at early age and it dwindled away with the advancement of age. This might be due to the large variation in the physical environment and the availability of palatable and nutritive fodder to the kids.

Baik et al. (1985) reported that season of birth had significant influence on body weights and measurements throughout the pre-weaning stage, kids born in spring or summer were heavier and grew faster than those born in autumn or winter.

Nagpal and Chawla (1985) examined the effects of various non-genetic factors on crossbred kids (Alpine x Beetal, Saanen x Beetal, Saanen x Alpine x Beetal and Alpine x Saanen x Beetal) born in winter, spring, summer and autumn. They reported that the influence of season was more pronounced at early stages in various crossbreds, kids born in spring (February-April) were heavier ($P < 0.05$) than those born in winter or autumn. This might be due to the difference in the availability of good quality and quantity of feeds to the does before parturition and to the kids after birth.

Naik et al. (1985) reported that season of birth had significant effect ($P < 0.01$) on body weights at birth, 6 month and 18 month.

Kids born in the months of November and December had higher body weight at birth and at 6 month. The reason might be the good fodder availability to the dams during gestation and to kids after birth.

Malik et al. (1986) analysed the data to find out the effects of various factors on birth weight, 30, 60 and 90 day weight of 1175 Beetal and Black Bengal kids by least-squares method. The kids were born in two seasons i.e. February-April and September-November. They reported that season of birth had significant effect on birth weight, 1 and 2 month weights, the kids born during February to April had higher mean body weight than those born during September-November. The variation in live weights in two seasons could be a reflexion of the availability of pasture to the dams during gestation and lactation as well as their kids at weaning.

Interaction (Type of Birth x Sex)

Barbieri et al. (1983) reported that in crossbreds, the sex differences were significant for twins, and the effect of type of birth was highly significant for female with regards to birth weight. At 38 days of age the effect of sex was highly significant in twins and the effect of type of birth was highly significant in both the sexes with regards to body weight. Type of birth had significant effect on daily gain in both the sexes.

Singh et al. (1983a) reported that interaction (type of birth x sex) was significant for most of the weights from birth to 48 weeks of age in Jamnapari goat.

Nagpal and Chawla (1984) reported that sex within litter size had significant effect on birth weight only and not on subsequent body weights in Beetal and Alpine goats.

Sarma et al. (1984) studied the interaction effect on body weight and measurements of 61 Assam local x Beetal kids of preweaning age. They reported that interaction between type of birth and sex of kid was not significant on any of the characters. Non-significant interaction probably indicated that the difference in body weights and body measurements due to type of birth were the same and/or common in both the sexes.

Nagpal and Chawla (1985) reported that in crossbreds (Alpine x Beetal, Saanen x Beetal, Alpine x Saanen x Beetal and Saanen x Alpine x Beetal), male kids born as single had higher ($P < 0.05$) birth weight than those born in multiple births. The influence of sexes within litter size was not so at later ages. The reason might be that the single kids were nourished better in pre- and post-natal life by their dams and males grew faster than females due to anabolic effect of sex hormone.

Dam's Weight at Kidding

Mohd-Yusuf et al. (1981) reported that there was no significant correlation between dam's weight at kidding and weaning weight in Katjang kids and their crosses (Saanen x Katjang, Anglo-Nubian x Katjang and Alpine x Katjang). However, it was significant for birth weight.

Ayoadae and Butterworth (1982) reported that weaning weight in Malawi goats was significantly correlated with dam's body weight at kidding.

Khan and Sahni (1983) examined the effects of various factors on body weights and measurements at birth, 1, 2 and 3 months of age in Jamnapari kids. They reported that weight of dam after kidding had significant effect on all the traits (body weight and body measurements) at all ages.

Malik et al. (1986) analysed the data by least-squares analysis taking dam's weight at kidding as covariate and found that it had a significant effect on body weight at birth, 1, 2 and 3 months of age in Beetal, Black Bengal goats and their crosses.

Heritability

Guha et al. (1968) studied variability for weights on 236 Black Bengal kids. They reported estimate of heritability for weight-gain estimated from Parental Half-sib Correlation to be 0.78 for female and 0.20 for male. Heritabilities as estimated by regression of body weight of progenies on post kidding weight of dams were 0.67, 0.15, 0.21 and 0.32 for weights at birth, 16 week, 36 week and 52 week, respectively.

Castillo et al. (1976) reported that heritabilities of body weights at birth, weaning, 6 and 12 months of age were 0, 0.39, 0.21 and 0.11, respectively.

Cyprus, Agricultural Research Institute, Annual Report (1981) detailed the heritabilities of live weights, pre-and post-weaning growth rates to be 0.24-0.31, 0.16 and 0.22, respectively (by Parental Half-sib Correlation method) in Damascus goat.

Ali (1983) conducted studies on Black Bengal goat and estimated heritabilities of 4-week weight and weaning weight as 0.086±0.178 for male and -1.924±0.443 for female, respectively at 4 week, corresponding values at weaning were 0.246±0.564 and 1.160±1.096. The large standard errors are probably due to limited number of sires and progeny per sire.

Mukandan et al. (1983) reported that heritabilities for body weights at 1, 2 and 3 months of age in Malabar and Saanen x Malabar goats were not significantly different from zero.

Darokhan and Tomar (1983) reported that heritabilities of body weight, body length, heart girth and withers' height at birth were 0.05±0.01, 0.05±0.14, 0.08±0.09 and 0.11±0.10, respectively. These were found to be not significantly different from zero indicating that no additive genetic variability was present among kids.

Madeli and Patro (1984) estimated heritabilities of birth weight, 6, 12, 18 and 24 month weights to be 0.185±0.139, 0.340±0.229, 0.357±0.257, 0.652±0.412 and 0.320±0.318, respectively. Since, birth weight was highly influenced by maternal effects, a low h^2 was quite expected. The h^2 of body weight at 18 months was highest suggesting that selection for body weight at this age would be most effective. The standard error values were a little high in all cases due to the reason that number of observations were not enough to get precise and reliable estimate.

Mavrogenis et al. (1984) estimated heritabilities for birth, weaning and 140-day weights and pre-and post-weaning growth rates by Parental Half-sib Correlation method. These were 0.31±0.08, 0.27±0.07, 0.21±0.07, 0.16±0.06 and 0.22±0.07, respectively. They suggested that despite the moderate values of h^2's, mass selection for rapid growth would be effective. Somewhat low heritability for post-weaning growth rate might be due to environmental factors not accounted for by the model used.

Malik et al. (1986) reported that heritabilities for birth weight, 1, 2 and 3 month weights were 0.23±0.03, 0, 0.08±0.07 and 0, respectively in Beetal. Corresponding values for Black Bengal goats were 0.21±0.05, 0.26±0.07, 0.43±0.09 and 0.20±0.08. The h^2's in Beetal were not significantly different from zero (except for birth weight).

Correlations Among Body Weights

Guha et al. (1968) reported on the basis of analysis of standard partial regression in Black Bengal goat that weight at 36 week had highest correlation with yearling weight and was least influenced by the weight at birth and at 16 weeks. The weight at 16 weeks was least dependable for selection. Birth weight also had a fair correlation with yearling weight though yearling weight was influenced by the weight at 16 and 36 weeks.

Wijeratne (1968) reported that phenotypic correlation of birth weight and 6 month live weight with 1 year live weight were 0.57±0.16 and 0.82±0.11, respectively in south Indian meat goat.

Cyprus, Agricultural Research Institute, Annual Report (1981) detailed the genetic correlations of weaning weight with pre-weaning growth rate and 140 day weight with post-weaning growth rate in Damascus goat as 0.98 and 0.90, respectively, corresponding phenotypic correlations were 0.95 and 0.85. These were found to be positive and highly significant.

Ayoadae and Butterworth (1982) reported that in Malawi and crossbred (Boer x Malawi) weaning weight was significantly correlated with birth weight (0.48 and 0.47, respectively).

Darokhan and Tomar (1983) calculated correlations amongst body weight and body measurements at birth in Changthang goats. The genetic correlation between birth weight and body length was positive and high but due to high standard error it was not precise. Phenotypic correlation between birth weight and body measurement (body length, heart girth and height at withers) were highly significant and positive. Phenotypic correlation between birth weight and heart girth and withers' height were positive and highly significant. Authors concluded that measurements could predict response to the correlated trait (body weight) in a desired direction.

Madeli and Patro (1984) studied the correlations among body weights at different ages in Ganjam goats. The genetic correlation between body weight at birth and at 6 month was positive and very high which indicated that similar genetic influence was prevailing in both the ages. Genetic correlations of birth weight with subsequent weights were negative which indicated that different genes controlled the body weight at subsequent ages.The corresponding phenotypic correlations were very low and insignificant. The genetic correlation between weights at 6 month and 18 months of age was high indicating that selection for 18 month body weight might be done on the basis of 6 month weight. Phenotypic correlations indicated that genetic and other influences on body weight of two consecutive ages were more similar than that of two distant ages from one year onwards.

Mavrogenis et al. (1984) reported highly positive genetic correlations between weaning and 140-day weights (0.82±0.08) and between preweaning growth rate and 140 day weight (0.80±0.10) and no genetic antagonism was found. The corresponding phenotypic correlations were 0.71 and 0.67.

Misra and Rawat (1984) analysed data by the weighted method of analysis of variance in Sirohi goats. The phenotypic correlations of weaning weight with body weight and measurements at birth were highly significant and non-significant, respectively, but significant with measurements at weaning. Authors suggested that birth weight could be used as a basis of selection for improving weaning weight.

Malik et al. (1986) studied correlations amongst body weights at birth, 1 2, and 3 months of age. They reported that all the pre-weaning weights were positively and significantly correlated among themselves at phenotypic level.

Regression of Body Weight on Age

Sarma et al. (1981) determined the regression of body weight on age (in days) for different factors in Assam local goats. They reported them as 35±2 gm for singles, 26±1 gm for twins, 33±1 gm for triplets; 34±2 gm for kids born in October-March and 31±1 gm for kids born in April-September. The estimates were tested by t-test and were found significant.

Khan and Sahni (1983) reported that regression of body weight (in kg.) on age (in months) was highly significant (b=2.603).

Mukundan et al. (1984) estimated regression of weight on age for 4 periods of the growth curve (0-3, 3-6, 6-9 and 9-12 months). Males grew faster in I growth phase only. The singlets grew faster than twins. The lowest rate was found in 4th period which indicated that the growth rate declined with increasing age.

WEIGHT-MEASUREMENT RELATIONSHIP AND PREDICTION OF BODY WEIGHT ON THE BASIS OF BODY MEASUREMENTS

Tandon (1966) studied the relationship between body weight and body measurements i.e. log length and log girth on 129 non-pregnant (74 aged less than 5 year and 55 more than 5 year), 90 pregnant goats (54 aged less than 2 year and 36 more than 2 year) and 99 young growing male stock (less than 1 year and upto 2 year), maintained at Government Livestock Farm, Hissar. The data was transformed into natural logrithims and simple and multiple correlations were calculated. It was found that log body weight was highly correlated with log length and log girth for all the groups. Correlations in above 6 groups, between log body weight and log length were 0.80, 0.63, 0.82, 0.67, 0.76 and 0.67, respectively, for log body weight with log girth, the corresponding correlations were 0.84, 0.59, 0.78, 0.87, 0.78 and 0.82, all being highly significant. The predication equations for log body weights were $Y=1.1269\ X_1 + 1.9974\ X_2 - 1.7139$ for non-pregnant goats below 5 years of age, $Y=1.4036\ X_1 + 0.9253\ X_2 - 1.5311$ for non-pregnant goats above 5 years of age, $Y=1.4175\ X_1 + 0.9742\ X_2 - 1.68$ for pregnant goats and $Y=0.9753\ X_1 + 1.7687\ X_2 - 2.1414$ for young growing male stock, where Y=log body weight, X_1=log length and X_2=log girth.

Singh (1975) studied body weight, length and heart girth of 511 kids belonging to Angora and Gaddi cross at birth, 1, 3, 6 and 12 months of age according to sex and breed group. Correlations between live weight and the body dimension at different ages were generally higher in females than the males. Heart girth was considered to be the best predictor of live weight in males (r=0.34 to 0.86) and females (r=0.26 to 0.80) at 12 months of age.

Mittal and Pandey (1978) studied growth rate in Barbari kids from birth to 9 months of age. They reported that the correlation coefficients between cannon length and body weight at birth 1, 2, 3, 4, 5, 6, 7, 8 and 9 months of age were 0.694, 0.835, 0.696, 0.258, 0.802, 0.675, 0.799, 0.707, 0.929 and 0.729, respectively in male kids. Corresponding values in female kids were 0.702, 0.796, 0.892, 0.788, 0.913, 0.832, 0.637, 0.855, 0.833 and 0.390. Highly significant correlations were found at most of the ages ($P < 0.01$) which indicated that there existed a close association between cannon length and body weight.

Falvey and Hengmichai (1979) studied some carcass traits of small ruminants in the northern highlands on 5 native goats, 7 Bangladesh-Burmese, 4 German mutton Merino x native and 3 Polworth x native sheep. They concluded that the best predictor of live weight and carcass weight was chest circumference (both correlations 0.93).

Misra (1980) analysed body weights as a function of some conformational traits in Sirohi goats. Data were recorded on body weight and body measurements i.e. body length, heart girth and paunch girth on 343 goats in 4 age groups from young kids to adults. Overall the equation for multiple regression of body weight on 3 body measurements had a R^2 value of 0.83. For goats with 4 permanent incisors the corresponding R^2 value was 0.85.

Prasad <u>et al.</u> (1981) calculated phenotypic correlation of body weight with body length, height and chest girth in 350 Black Bengal she-goats of 5 age group i.e.0-3 months, 3-6 months 6-12 months, 1-3 years and above 3 years of age in 3 agro-climatic zones (plain, plateau and subplateau). They observed that (1) correlations between body weight and length, height and heart girth in I age group in plains were 0.83, 0.91 and 0.98, respectively, and corresponding figures in 5th group were 0.57, 0.54 and 0.92, all being highly significant. (2) Correlations between body weight and chest girth in different age groups in the same region were 0.98, 0.14, 0.88, 0.78 and 0.92, all significant. (3) Partial regression coefficients of body weight on length, height and chest girth were 0.15, -0.02 and 0.75 in group 4 i.e. 1-3 years of age and found to be significant for chest girth only. (4) Equation for predicting body weight of goats in group 4 (1-3 year) was given as $Y=49.67+0.15\ X_1\ -0.02\ X_2\ +\ 0.75\ X_3$ where Y=Body weight, X_1=length, X_1=height at withers and X_3 = chest girth. The equation had a R^2 value of 0.75. On the basis of above findings authors concluded that (1) majority of correlations are significant in all age groups and these correlations are higher in early stage of growth and gradually declined with increase in age. (2) Correlations of body weight with chest girth were highest in majority of cases followed by length and height respectively. Closer relationship between body weight and chest girth can be explained by intimate association between body weight and growth of muscle, bones and visceral organs. (3) Chest girth may be considered as an important measurement in predicting live weight.

Valdez et al. (1982) calculated phenotypic correlation between body weight and body measurements i.e. length, chest circumference, height at withers, midrift circumference and flank circumference for 603 goats of several breeds and crosses in Philippines. They found that (1) The squared correlation (R^2) between body weight and chest circumference was 0.90. (2) The squared multiple correlation of chest circumference + wither height with body weight was 0.91. They concluded that their existed a high correlations between body weight and chest circumference.

Darokhan and Tomar (1983) calculated genetic, phenotypic and environmental correlations between birth weight and body measurements (length, heart girth and height at wither) at birth in Changthang goats. The genetic parameters were estimated according to Hazel et al. (1943) and Searle (1961) and standard errors according to Robertson (1959) and Panse and Sukhatme (1967). The phenotypic correlations between birth weight and body length, heart girth and height at withers were reported in males as 0.53±0.06, 0.79±0.05 and 0.82±0.03, respectively, corresponding values in case of female were 0.45±0.07, 0.53±0.08 and 0.43±0.08. All correlations were significant ($P < 0.01$). Genetic correlation between birth weight and body length was 0.83±0.56 in males and 0.57±1.58 in case of females. Authors concluded that the genetic correlation between birth weight and body length was positive and high but due to high standard error it was not precise. All the phenotypic correlations were positive and highly significant. Phenotypic correlation between birth weight and heart girth and between birth weight and height at withers were positive and highly significant.

Mukherjee et al. (1983) studied body weight-measurement relationship in 212 Grey Bengal goats of 5 age groups (0-3, 3-6, 6-12 months, 1-3 year and above 3years) in 3 different agroclimatic zones, viz. (a) Gangetic plain, (b) Plateau and (c) Subplateau. They observed that (1) phenotypic correlations between body weight and each of the 3 body measurements (length, height and chest girth) for 0-3, 3-6 and 6-12 months age groups were 0.87±0.16, 0.93±0.11 and 0.92±0.11, 0.76±0.21, 0.57±0.21 and 0.96±-0.09 and 0.67±0.21, 0.64±0.25 and 0.92±0.13, respectively in plain region. (2) Except in 3-6 month age group in plateau, the correlation of body weight with chest girth was significant in all the cases. Next to chest girth was body length. Authors concluded that (1) chest girth may be an important measurement as it is highly correlated with body weight. This is possibly due to the fact that chest girth constitute a major part of body weight at all stages of life. (2) Next to chest girth was the associations of body weight and body length and association of height with body weight was significant in least number of cases.

Bhattacharya et al. (1984) developed multiple regression equations to estimate body weights from body measurements, from the data recorded on 135 female Black Bengal goats maintained at University Goat Farm, Mohanpur. They observed that (1) The coefficient of determination is maximum (R^2=0.84) when heart girth, length and neck circumference were taken. (2) The coefficient of determination was quite comparable to the above for the equations with all four measurements (X_1=heart girth, X_2=height, X_3=Length and X_4=Neck circumference), with X_1 and X_4 and with X_1 and X_3 (R^2 values 0.842, 0.833 and 0.834, respectively). (3) The multiple regression equation i.e. prediction equation $Y=-24.538+0.487\ X_1+0.232\ X_3$ and $Y=-23.839+0.524\ X_1+0.266\ X_4$ were found to be equally most effective with coefficient of multiple correlation approximately 0.91, where Y=body weight in kg., X_1, X_2 and X_4 are heart girth, length and neck circumference in cm., respectively. Authors concluded that with the aid of measuring tape graduated in cm., the body weight of small animals such as goat can be calculated with a reasonable degree of accuracy, where there is no provision for weighing machine.

Bose and Basu (1984) studied relationship between body measurements (body length, withers' height, heart girth, chest floor height, chest depth, paunch girth, lip-width and loin width) and meat production based on 125 males aged less than 1 year and 145 females aged about $2\frac{1}{2}$ years. They employed the stepwise regression procedures for screening the array of body measurements components to determine the combination that best (maximum R^2) explains variation in the dependent variables i.e. the meat production traits. They observed that (1) the body measurements, particularly length, height, chest and paunch girth were strongly correlated with slaughter weight (0.608 to 0.892) and carcass weight (0.570 to 0.845) and these correlations coefficients of body measurements with body weight were higher in males. (2) The live weight at the time of slaughter was most affected by heart-girth with R^2 value at 79.6%. (3) Cumulative R^2 values on entering other independent variables such as length, paunch girth, height, loin-width and chest depth were 82.6, 84.1, 85.4, 85.8 and 85.9 percent respectively. They concluded that (1) live weight can be predicted from body measurements. (2) Selection based on body length, slaughter grade, width of the loin and live weight will improve meat production in goats.

Manik et al. (1984) predicted body weight from body measurement, on 102 beetal, 97 Alpine x Beetal and 47 Saanen x Beetal goats and calculated correlation coefficients between body weight and each of the three body measurements i.e. length, height at withers and heart girth. They observed that (1) Correlation coefficients between body weight and length, height and girth were 0.924, 0.882 and 0.931 for Beetal. (2) Corresponding values for Alpine X Beetal and Saanen x Beetal were 0.921, 0.886, 0.945 and 0.937, 0.879 and 0.946 respectively. All the correlations were positive and significant and correlation of body weight with chest girth was highest in all breeds. (4) Y=40.53 + 0.684(CG) + 0.147(BL) - 0.09(HW) for Beetal, Y=-47.81 + 1.216(CG) + 0.151(BL) - 0.253(HW) for Alpine x Beetal and Y=-41.59 + 0.912(CG) + 0.732(BL) - 0.627(HW) for Saanen x Beetal were the prediction equation developed by stepwise multiple regression method, where Y is Body weight, CG=Chest girth, BL=Body length and HW=Height at withers. Author concluded that prediction of body weight by multiple regression equations gave slightly more accurate result than the estimation from chest girth alone, but latter would be easier to work. They also suggested that selection on the basis of these body measurements were likely to improve meat production potential of goats.

Misra and Rawat (1984) examined the effects of various factors on pre-weaning weights and configuration on 242 Sirohi kids. They determined correlation coefficients between weaning weight (90 day weight) and body measurements (length, heart-girth, paunch girth and height at withers) at birth and at weaning. The correlation coefficients between weaning weight and body measurements at birth i.e. length, heart girth, paunch girth and height at withers were -0.058, 0.015, 0.118 and -0.038, respectively. All these correlations were not significantly different from zero. Corresponding values at weaning were 0.793, 0.857, 0.827 and 0.713 and were highly significant ($P < 0.01$).

Chapter - 3

geneticanalysisofgrowthfrombirthtotwelvemonthsofageinjamnaparigoats

MATERIALS AND METHODS

geneticanalysisofgrowthfrombirthtotwelvemonthsofageinjamnaparigoats

MATERIALS AND METHODS

Source of Data

In the present investigation data on body weight, body length, height at withers and chest girth from birth to 12 months of age at monthly interval and weight of dam at kidding, recorded on 524 Jamnapari kids sired by 12 bucks and maintained at Central Institute for Research on Goats, Makhdoom, Mathura (UP), during 1982 to 1984 were used.

Management and Hygiene

The enitre flock was kept in 6 sheds which were cleaned daily in the morning. Breeding bucks, weaned males and females were kept separately. All sheds were dug and scrapped 6" deep and earth was replaced periodically. Fresh lime was used for disinfection of sheds. There were 2 kidding sheds (100' x 20') with individual kidding pans (5' x 4'). Other sheds were of the size of 100'x 20' with five portions each of 20' x 20' size. After kidding, udder of the dam was cleaned with $KMnO_4$ and naval treatment was done with Tincture Iodine. Marking of kids and their dams was done with $AgNO_3$ to identify kids and does at the time of milk feeding. Goats were sent out for grazing after 15 days of kidding.

Feeding

1. Newly born kids were kept with their dams for 7 days and thereafter they were fed only on milk from their dams for 10-15 minutes 4 times a day with an interval of 6 hours until they attained 15 days of age.
2. Kids from 15 days - 1 month of age were provided with dam's milk thrice a day with an interval of 8 hours. They were kept on creap, green and tender fodder.
3. Kids from 1-3 months of age were allowed to suckle their dams 2 times a day i.e. morning and evening. They

nibbled on creap mixture, mineral mixture, saltlick and green fodder.

4. Kids over 3 months of age were weaned and were sent for grazing for 6-7 hours daily. The vegetation, although scanty, consisted of Anjan grass, Dub grass, Babul pods, Pilloo, Ghiabati, Chatta etc., besides this, loppings from Babul, Neam and Chonkra etc. were also available. Except for monsoon season the vegetation was not sufficient.
5. Animals from 3 months to 1 year of age were provided with 300 gm/day growth mixture (ration)/head and 2-3 kg. green fodder as per the availability with 6-7 hours grazing.
6. Supplementary feeding was done for adults (more than 1 year) with 500 gm/day (morning and evening) and for does in late pregnancy the quantity was increased upto 600 gm/day.
7. Tap water was provided ad lib. to each and every individual.

Composition of Concentrate

Ingredients	Adult	Growth	Creap
Maize	25	50	50
Groundnut cake	32	15	10
Wheat bran	40	20	07
Barley/Oats	-	10	20
Fish meal	-	-	10
Mineral Mixture	02	02	02
Salt	01	03	01
Total	**100**	**100**	**100**

Fodder Available

December to May	-	Berseem, Lucern.
May to June	-	Lucern.
June to November	-	Maize, Guar & MP Chari.

Body Weights and Measurements

Body weight and measurements were recorded at birth (within 12 hours of birth) and thereafter, at monthly interval upto 12 months of age. Records were taken between 7.00 to 10.00 am. daily before kids were provided with feed and water. Weights of new born kids were taken by pan balance (10 kg. capacity) and thereafter with spring balance as well as plateform balance according to the age of the animal. Measurements were recorded by measuring cloth tape (graduated in centimeters).

Breeding

Heat detection was done twice a day i.e. in morning and evening with the help of teaser. Pure breeding system was adopted and Hand mating was done in morning and evening after the heat detection.

Dam's body weight at kidding

Body weight of each dam which had kidded was recorded within 8 hours of parturition on plateform balance with 100 kg. capacity. Before weighing, it was ensured that the doe had expelled the placenta after kidding.

STATISTICAL METHODS

The following statistical methods were utilized in the present investigation:-

Averages, Standard Errors and Coefficients of Variation

The averages, standard errors and coefficients of variation of body weight and body measurements at different ages were calculated by the following formulae:-

Mean

$$\overline{X} = \frac{1}{n} \sum_{i=1}^{n} X_i$$

Where,

$\overline{X}$ stands for mean of any character (X), $\sum_{i=1}^{n} X_i$ is sum of the observations on X_i and n is the total number of observations.

Standard Error (SE)

Standard deviation (SD) = $\sqrt{\text{variance}}$

$$S.E.(\overline{X}) = \frac{SD}{\sqrt{n}}$$

Where,

X is a character and n is the total number of observations on X.

Coefficient of Variation (CV)

$$CV(\%) = \frac{SD}{\overline{X}} \times 100$$

Where,

SD is standard deviation and $\overline{X}$ is the mean of the character X.

Method for Analysis of Non-Orthogonal Data

Data were analysed by least-squares technique (Harvey, 1976) to study the effects of various genetic and non-genetic factors on body weights and body measurements at different ages (from birth to 12 months of age). The mathematical model used for this purpose was:-

$$Y_{ijklmn} = \mu + S_i + Y_j + T_k + Sx_l + M_m + (T \times Sx)_{kl} + bD_{ijklmn} + e_{ijklmn}$$

Where,

Y_{ijklmn} = Value of n^{th} individual in $(ijklm)^{th}$ cell,

μ = General effect,

Si = Effect of i^{th} sire chosen at random (i=1,2,...,12),

y_j = Effect of j^{th} year of birth (j=1,2,3),

T_k = Effect of k^{th} type of birth (K=1,2,3),

Sx_l	=	Effect of l^{th} type of sex (l=1,2),
M_m	=	Effect of m^{th} month of birth (m=1,2,...,8),
$(T \times Sx)_{kl}$	=	Interaction between K^{th} type of birth and l^{th} sex,
b	=	Partial regression coefficient of character (Y_{ijklmn}) on dam's weight after kidding,
D_{ijklmn}	=	Dam's weight at kidding of n^{th} individual in $(ijklm)^{th}$ cell and
e_{ijklmn}	=	Random error associated with $ijklmn^{th}$ kid's value with mean 0 (zero) and variance σ_e^2.

Sires were chosen at random; dam's weight after kidding was taken as covariate and all other effects considered were taken as fixed effects.

Least-squares Analysis

The main purpose of this technique is to minimise error sum of squares between the observed and expected values.

$$\sum_{ijklmn} e^2_{ijklmn} = (\hat{Y}_{ijklmn} - u - y_j - T_k - Sx_l - M_m - (T \times Sx)_{kl} - b)^2$$

Least-square Methodology

The technique comprises of following four steps:-

1. Computation of least-square equations.
2. Imposition of restrictions.
3. Estimation of constants and least-square means.
4. Analysis of variance.

1. Computation of Least Square Equations

The normal equations were formed by partially differentiating the error sum of squares with respect to all the least-square constants to be estimated. In this way there will be one equation separately for each of the constants. Equations for sires were absorbed. The complete set of equations contained in the model is given in the following table:-

Character	u	Year of Birth	Type of Birth	Sex	Month of Birth	Int.	Reg.	Total (n)
Weights and Measurements								
At birth	1	3	3	2	8	6	1	24
At 1 month	1	3	3	2	8	6	1	24
At 2 months	1	3	3	2	8	6	1	24
At 3 months	1	3	3	2	8	6	1	24
At 4 months	1	3	3	2	8	6	1	24
At 5 months	1	3	3	2	8	6	1	24
At 6 months	1	3	3	2	7	6	1	23
At 7 months	1	3	3	2	6	6	1	22
At 8 months	1	3	3	2	6	6	1	22
At 9 months	1	2	3	2	6	6	1	21
At 10 months	1	2	3	2	6	6	1	21
At 11 months	1	2	3	2	6	6	1	21
At 12 months	1	2	3	2	6	6	1	21

From above table matrix of n x n order was generated for different characters.

2. Imposition of Restrictions

The restriction that sum of the constants estimated in a given set equals to zero was used to get reduced matrix.

3. Estimation of Constants and Least-square Means

The inverse matrix of the reduced matrix was obtained and the estimates of the constants were obtained with the help of following equation:-

$$\hat{C}_i = \Sigma C^{ij} Y_j$$

Where,

$\hat{C}_i$ is the estimate of i^{th} constant, C^{ij} is the inverse element corresponding to i^{th} row and j^{th} column of the complete inverse matrix and Y_j is the value of the j^{th} element of the reduced column vector.

The standard error of least-square mean was obtained as follows:-

$$SE(u + \hat{C}_i) = \sqrt{(C^{II} + C^{ii} + 2C^{Ii})\hat{\sigma}_e^2}$$

Where,

C_i is i^{th} constant; C^{II} is diagonal inverse element for u; C^{ii} is the corresponding diagonal inverse element for the constant and C^{Ii} is the off diagonal element corresponding to first row and i^{th} column. $\hat{\sigma}_e^2$ is the error mean square.

4. Analysis of Variance

The sum of squares for each effect was obtained from the inverse of the corresponding segment of the inverse matrix and the least-square constants by the formula given below:-

$$SS = B'Z^{-1}B$$

where,

B' is the row vector of the reduced constant estimates for a given set. Z^{-1} is the inverse of the segment of the inverse of complete matrix correspondng to row and column to this set of constants and B is the column vector of the reduced constant estimates for this set.

Error sum of squares was obtained as:-

$$\text{Error S.S.} = \sum_{ijklmn} Y^2_{ijklmn} - \text{S.S. (due to all constants)}$$

After this analysis of variance table was set up whose out lines are given in the following table:-

Source of Variation	df	SS	MS	F
Between Year of Birth	y-1	$Y'Z^{-1}Y$	MS_Y	MS_Y/MS_e
Between type of Birth	t-1	$T'Z^{-1}T$	MS_T	MS_T/MS_e
Between Sex	sx-1	$Sx'Z^{-1}Sx$	MS_{Sx}	MS_{Sx}/MS_e
Between Month of birth	m-1	$M'Z^{-1}M$	MS_m	MS_m/MS_e
Interaction	(t-1)(sx-1)	$I'Z^{-1}I$	MS_I	MS_I/MS_e
Regressin	1	$b'Z^{-1}b$	MS_R	MS_R/MS_e
Error	N-[y+t+sx+m +(t-1)(sx-1)] +2	Y^2-SS due to all constants	MS_e	
Total	**N-1**			

Duncan's Multiple Range Test

Duncan's multiple range test (Duncan, 1955) modified by Kramer (1957), was used to examine pair-wise comparisons among the means with the use of inverse estimates and the error mean square.

If the value

$$(\bar{Y}_i-\bar{Y}_j)\sqrt{\frac{2}{(C^{ii}+C^{jj}+2C^{ij})}}$$

is greater than $\sigma_e . Z_{p,n_e}$, then the difference is significant.

Where,

$\bar{Y}_i - \bar{Y}_j$ = Difference between the two means.

C^{ii} = Corresponding i^{th} diagonal element of C matrix.

C^{jj} = Corresponding j^{th} diagonal element of C matrix.

C^{ij} = Corresponding off diagonal element.

Z_{p, n_e} = Studentized range value in Duncan's table at n_e degrees of freedom and p is the number of means in the range chosen.

n_e = Error degrees of freedom

σ_e^2 = Error mean square.

Adjustment of Data

Once the least-squares constants were obtained, observations were corrected for the significant effects of year of birth, type of birth, sex, month of birth and regression. Correction factor was calculated as follows:-

CF for n^{th} individual in $(ijklm)^{th}$ cell = $Y_j + T_k + Sx_l + M_m + R$

The correction factors so obtained were used to adjust the various records for each character of the individual animal as follows:-

Adjusted $Y_{ijklmn} = Y_{ijklmn} - CF$

The adjusted records were used to estimate various phenotypic and genetic parameters.

Phenotypic Correlation

Phenotypic correlations were calculated by the following formula:-

$$r_p = \frac{CovP_{xy}}{\sigma_{P_x} \; \sigma_{P_y}}$$

Where,

r_p = Phenotypic correlation between two traits X & Y,

$CovP_{xy}$ = Phenotypic covariance between X & Y,

σ_{P_x} = Phenotypic standard deviation of variate X and

σ_{P_y} = Phenotypic standard deviation of variate Y

Test of Significance of Correlation Coefficients

The phenotypic correlation coefficients were tested for their statistical significance by t-test.

$$t = \frac{r\sqrt{n-2}}{\sqrt{1-r^2}} \text{ on (n-2) degrees of freedom.}$$

Where,

n is the number of pairs.

Genetic Correlation

Genetic correlations were calculated by the following formula:-

$$r_{G_{xy}} = \frac{Cov\ S_{xy}}{\sigma_{S_x}\ \sigma_{S_y}}$$

Where,

$r_{G_{xy}}$ = Genetic correlation between 2 traits (X and Y),

$Cov\ S_{xy}$ = Genetic covariance between X and Y,

σ_{S_x} = Genetic standard deviation of variate X and

σ_{S_y} = Genetic standard deviation of variate Y

Standard error of genetic correlation was calculated by the following formula (Robertson, 1959) :-

$$S.E.(r_G) = (1 - r_G^2)\sqrt{\frac{S.E.(h_x^2) \times S.E.(h_y^2)}{2 \times h_x^2 \times h_y^2}}$$

Where,

h_x^2 and h_y^2 are heritabilities of the two traits (X and Y).

Regression Coefficients

Regression coefficients were calculated by the following formula:-

$$b_{y.x} = \frac{CovP_{xy}}{\sigma_x}$$

Where,

$b_{y.x}$ = Regression of Y on X

$CovP_{xy}$ = Phenotypic covariance betwen X and Y

σ_x = Phenotypic standard deviation of variate X.

Test of Significance of Regression Coefficients

The regression coefficients were tested for their statistical significance by using t-test.

$$t = \frac{b}{SE(b)}$$ on (n-2) degrees of freedom

Where, n is the number of pairs.

Multiple Regression

The multiple regression of body weight on 3 linear body measurements at different ages were determined and following multiple regression equations were fitted:-

$$Y = \alpha + b_{y1} X_1$$

$$Y = \alpha + b_{y2} X_2$$

$$Y = \alpha + b_{y3} X_3$$

$$Y = \alpha + b_{y1.2} X_1 + b_{y2.1} X_2$$

$$Y = \alpha + b_{y1.3} X_1 + b_{y3.1} X_3$$

$$Y = \alpha + b_{y2.3} X_2 + b_{y3.2} X_3$$

$$Y = \alpha + b_{y1.23} X_1 + b_{y2.13} X_2 + b_{y3.12} X_3$$

Where,

α = general effect

Y = body weight

X_1 = body length

X_2 = height at withers

X_3 = heart girth

b_{y1} = regression of Y on X_1

b_{y2} = regression of Y on X_2

b_{y3} = regression of Y on X_3

$b_{y1.2}$ = partial regression coefficient of Y on X_1, when X_2 held constant.

$b_{y2.1}$ = partial regression coefficient of Y on X_2, when X_1 held constant

$b_{y1.3}$ = partial regression coefficient of Y on X_1, when X_3 held constant

$b_{y3.1}$ = partial regression coefficient of Y on X_3, when X_1 held constant

$b_{y2.3}$ = Partial regression coefficient of Y on X_2, when X_3 held constant

$b_{y3.2}$ = partial regression coefficient of Y on X_3, when X_2 held constant

$b_{y1.23}$ = partial regression coefficient of Y on X_1, when X_2 and X_3 held constant.

$b_{y2.13}$ = partial regression coefficient of Y on X_2, when X_1 and X_3 held constant.

$b_{y3.12}$ = partial regression coefficient of Y on X_3, when X_1 and X_2 held constant.

Test of Significance of Regression Coefficients

The partial regression coefficients were tested for their statistical significance by t-test.

$$t = \frac{b}{SE\ (b)} \quad \text{on (n-m) degrees of freedom.}$$

Where,

n is the number of pairs and m is the number of variates.

The multiple correlation coefficient, R, between Y and combined influence of X_1, X_2 and X_3 was obtained by the following formula:-

$$R^2 = \frac{b_1[\Sigma X_1 Y - \frac{(\Sigma X_1)(\Sigma Y)}{n}] + b_2[\Sigma X_2 Y - \frac{(\Sigma X_2)(\Sigma Y)}{n}] + b_3[\Sigma X_3 Y - \frac{(\Sigma X_3)(\Sigma Y)}{n}]}{\Sigma Y^2 - \frac{(\Sigma Y)^2}{n}}$$

Heritability

Heritability is the ratio of additive genetic variance to the total phenotypic variance. Knowledge of heritability for a character is of great importance in the selection and breeding practices since it is the fraction which is being transmitted from parents to their offspring.

After making adjustments for the significant effect of various factors the data were arranged according to sires and then one way analysis of variance was done to find out the sire and error components of variance. As the offspring inherits only half of the genic composition of sire, the variance among sires measures 1/4th of the genetic variation.

Therefore, $\sigma_S^2 = V(S) = V(\frac{1}{2}V_A) = \frac{1}{4}V_A$, and consequently $4\sigma_A^2 = V_A$.

Thus the heritability was obtained as:-

$$h^2_{(S)} = \frac{V_A}{V_P} = \frac{4\sigma_S^2}{\sigma_P^2} = \frac{4\sigma_S^2}{\sigma_S^2 + \sigma_e^2}$$

The model used for this purpose was:-

$$Y_{ij} = u + S_i + e_{ij}$$

Where,

i = 1, 2, ..., S

j = 1, 2, ..., n_i

S = Number of Sires.

n_i = Number of observations under i^{th} Sire.

Y_{ij} = The value of j^{th} progeny under i^{th} Sire

e_{ij} = Random error associated with Y_{ij}, normally and independently distributed with mean zero and variance σ_e^2.

The analysis of variance for half-sib data with unequal number of progenies under different sires was done as follows:-

Source	df	S.S.	M.S.	E.M.S.
Between Sires	S-1	$\sum_{i=1}^{s} \frac{Y_{i.}^2}{n_i} - \frac{(Y_{..})^2}{N}$	MS_s	$\sigma_e^2 + k\,\sigma_s^2$
Within Sires	N-S	$\sum_{ij} Y_{ij}^2 - \sum_{i=1}^{S} \frac{Y_{i.}^2}{n_i}$	MS_e	σ_e^2

Where,

$$k = \frac{1}{S-1}\left(N - \frac{\Sigma n_i^2}{N}\right)$$

S = Total number of sires.

σ_s^2 = Sire component of variance.

σ_e^2 = Error component of variance.

$$\sigma_s^2 = \frac{MS_s - MS_e}{k}$$

Standard error of heritability was obtained by using the following formula:-

$$SE(h^2) = \frac{4}{\sigma_s^2 + \sigma_e^2}\sqrt{\frac{2}{k^2}\left[\frac{(MS_s^2)}{S-1} + \frac{(MS_e^2)}{N-S}\right]}$$

Chapter - 4

geneticanalysisofgrowthfrombirthtotwelvemonthsofageinjamnaparigoats

RESULTS AND DISCUSSION

geneticanalysisofgrowthfrombirthtotwelvemonthsofageinjamnaparigoats

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BIRTH WEIGHT

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Genetic improvement in body weight can be done by selection. Birth weight is the first observation which can be used as a criterion to select heavier animals, since animals with higher birth weight are generally heavier at later ages (Dutta et al., 1963; Guha et al., 1968; Ali, 1980 and Ayoadae and Butterworth, 1982). It also has direct bearing on mortality of kids during early life, the kids with low birth weight have low survivability (Mittal, 1976 and Prasad, 1983). Birth weight is influenced by many factors such as sex (Singh et al., 1977), type of birth (Khan and Sahni, 1983) season of birth (Castillo et al., 1976), year of birth (Montaldo and Juarez, 1980) etc.

The present investigation was undertaken to find out influence of different factors (year, month and type of birth, sex of kid, interaction (type x sex), sire and dam's weight at kidding) on birth weight and its correlation with subsequent weights in Jamnapari goats.

Data on body weights from birth to 12 months of age and dam's weight at kidding on 524 kids sired by 12 bucks maintained and recorded at Central Institute for Research on Goats, Makhdoom, Mathura (UP) during 1982-84 were used.

Least-squares technique (Harvey, 1976) was used to study the effect of various factors. Heritability and correlations were estimated according to Hazel and Terril (1946) and Snedecor and Cochran (1968), respectively.

Average, Standard Error and Coefficient of Variation

Averages of birth weight along with standard errors and coefficients of variation for different factors are detailed in Table 1.1. It was seen that singles were heavier than twins or triplets and so also males as compared to females. Overall birth weight averaged 3.354 ± 0.032 kg. The variability in birth weight (CV) was highest (27.98) for triplets and lowest (10.75) for kids born in February.

Least-Squares Analysis

It was hypothesized *a priori* that the birth weight was affected by year, month and type of birth, sire, sex of kid, interaction (type x sex) and weight of dam at kidding. Sires were chosen at random. The data were analysed using least-squares analysis of variance (Harvey, 1975), since the data were non-orthogonal. The details of least-squares analysis of variance are given in Table 1.2.

Analysis of variance showed the effects due to year, type and month of birth, sex and dam's weight at kidding to be highly significant ($P < 0.01$). Sire and interaction (type of birth x sex) did not affect birth weight significantly.

The least-squares constants along with the standard errors of their respective least-square means are given in Table 1.3. Kramers modification of Duncan's multiple range test was applied to test the significance between pairs of means and results are presented along with the constants.

Effect of Various Factors on Birth Weight

The effect of year of birth was found to be significant on birth weight. Kids born in the year 1983 had significantly higher birth weight than those born in 1982 and 1984. Kids born in 1984 were having lowest birth weight.

The influence of type of birth was highly significant ($P < 0.01$) on birth weight. Single born kids were significantly heavier than twins and triplets. Twin born kids were heavier than triplets.

Sex of kid had a significant effect ($P < 0.01$) on birth weight. The male kids were found to be heavier than females.

The influence of month of birth was found to be significant on birth weight ($P < 0.01$). Kids born in February-March period were heavier than those born in other months.

The influence of interaction of type of birth and sex of kid was found to be non-significant.

Dam's weight at kidding had a significant effect on birth weight ($P < 0.01$).

Correlation Between Birth Weight and Dam's Weight at Kidding

The phenotypic correlation between dam's post-kidding weight and birth weight was estimated to be 0.21 and was significant ($P < 0.05$).

Heritability

The heritability of birth weight could not be estimated, since the variance component of sire was found to be negative.

Correlation of Birth Weight with Subsequent Body Weights

Phenotypic correlation between birth weight and body weights from 1 to 12 months of age are presented in Table 1.4. Birth weight had positive and highly significant correlation with weights at 1, 2, 3 and 5 months of age ($P < 0.01$). It was significantly correlated with 4 month weight ($P < 0.05$). Correlation of birth weight with wieghts at 6 months and at subsequent ages were found to be non-significant.

Table 1.1 : Averages of Birth Weight with Standard Errors and Coefficients of Variation for Different Factors in Jamnapari Goats

Factors	Number of Observations	Mean	Standard Error	Coefficient of Variation
1. <u>Sex</u>				
Male	258	3.559	0.045	20.212
Female	266	3.154	0.042	21.625
2. <u>Type of Birth</u>				
Single	226	3.669	0.046	18.869
Twin	281	3.126	0.039	20.851
Triplet	17	2.923	0.198	27.986
3. <u>Year of Birth</u>				
1982	78	3.121	0.084	23.877
1983	289	3.514	0.042	20.467
1984	157	3.175	0.053	21.009
4. <u>Month of Birth</u>				
February	15	3.507	0.097	10.749
March	156	3.518	0.063	22.393
April	7	2.871	0.164	15.142
May	28	2.939	0.120	21.683
September	127	3.167	0.058	20.511
October	8	3.350	0.248	20.926
November	73	3.104	0.079	21.905
December	110	3.618	0.064	18.705
Overall	**524**	**3.354**	**0.032**	**21.729**

Table 1.2 : Least Squares Analysis of Variance for Various Factors Affecting Birth Weight in Jamnapari Goats

Source of Variation	d.f.	M.S.	F
Sire	11	0.188	0.718
Year of birth	2	11.469	43.716**
Type of birth	2	23.332	88.936**
Sex of kid	1	3.489	13.300**
Month of birth	7	6.462	24.633**
Type of birth x Sex	2	0.113	0.429
Regression			
Dam's weight at kidding	1	26.448	100.814**
Error	497	0.262	

*Significant at $P < 0.05$, **Significant at $P < 0.01$

Table 1.3 : Least-square Constants for Various Factors Affecting Birth Weight with Duncan's Multiple Range Test

Effect	Constant ± S.E. [L.S. Mean]
u	3.129 ± 0.060
Year of Birth	
1982	0.100 ± 0.097[b]
1983	0.357 ± 0.070[a]
1984	-0.457 ± 0.083[c]
Type of Birth	
Single	0.537 ± 0.053[a]
Twin	-0.074 ± 0.050[b]
Triplet	-0.462 ± 0.135[c]
Sex	
Male	0.164 ± 0.079
Female	-0.164 ± 0.070
Month of Birth	
February	0.397 ± 0.146[ab]
March	0.485 ± 0.071[a]
April	0.185 ± 0.211[abc]
May	0.069 ± 0.126[bc]
September	-0.549 ± 0.073[d]
October	-0.219 ± 0.190[cd]
November	-0.389 ± 0.081[d]
December	0.021 ± 0.071[c]
Type of Birth x Sex	
Single male	-0.004 ± 0.062
Single female	0.004 ± 0.064
Twin male	0.035 ± 0.060
Twin female	-0.035 ± 0.057
Triplet male	-0.031 ± 0.201
Triplet female	0.031 ± 0.169
Regression	
Dam's Weight at Kidding	0.036 ± 0.004

Means of the various factors under same superscript were not significantly different from each other

Table 1.4 : Phenotypic Correlations Between Birth Weight and Subsequent Body Weights

Body Weight At	Number of Observations	Correlation Coefficient
1 Month	437	0.472**
2 Month	418	0.318**
3 Month	390	0.265**
4 Month	321	0.244*
5 Month	273	0.257**
6 Month	313	0.199
7 Month	170	0.117
8 Month	120	0.088
9 Month	211	0.113
10 Month	95	0.095
11 Month	69	0.159
12 Month	148	0.190

*Significant at $P < 0.05$, **Significant at $P < 0.01$

DISCUSSION

Average

Average birth weight of Jamnapari kids was 3.354±0.032 kg. For males it was 3.559±0.045 and females 3.154±0.042 kg. These findings are in general agreement with the findings of Dutta et al. (1963), Johri and Talpatra (1971), Mittal and Pandey (1974). The birth weight in the present investigation was found to be more than the weight reported by Khan and Sahni (1983), Kumar and Singh (1983) and Singh et al. (1983b), but less than the weight reported by Singh (1973).

Effects of Various Factors on Birth Weight

The effect of sire, year of birth, type of birth, sex, month of birth, interaction (type of birth x sex) and dam's weight at kidding were examined by least-squares technique (Harvey, 1976).

Sires were chosen at random and their effect was found to be non-significant. This finding is similar to the report of Singh (1973). Birth weight had very small additive genetic variance (Darokhan and Tomar, 1983 and Madeli and Patro, 1984) and is highly influenced by maternal influence. The non-significant effect of sires on birth weight may be due to its being affected by maternal influence.

It was observed that year of birth had a significant effect on birth weight ($P < 0.01$). Birth weight of kids born in the year 1983 was higher than those born in 1982 and 1984. The kids born in year 1982 were heavier than those born in 1984. Significant effect of year of birth on birth weight have been reported in various breeds (Guha et al., 1968; Castillo, et al. 1976; Montaldo and Juarez, 1980; Darokhan and Tomar, 1983 and Nagpal and Chawla, 1984). Significant differences among years can be partly explained by the differences in management and climatic conditions in those years.

The effect of type of birth on birth weight was found to be highly significant ($P < 0.01$) and the trend observed was singles being heaviest followed by twins and triplets. (Table 1.3). These findings are in close agreement with Sarma et al. (1981), Khan and Sahni (1983), Ozekin and Akcapinar (1983), Singh et al. (1983a), Mavrogenis et al. (1984), Sarma et al. (1984), Baik et al. (1985) and Malik et al. (1986) in various breeds. The heavier birth weight of single born kids as compared to twins or triplets may be due to the reason that does with more than one kid could not provide sufficient prenatal care to each kid. Single born kids received more nutrients from their dams and therefore, heavier than twins and triplets.

In the present investigation it has been found that sex of kid had highly significant effect on birth weight ($P < 0.01$); the male kids being heavier than the females. Present findings are similar to the earlier reports in Jamnapari and other breeds (Darokhan and Tomar, 1983; Ozekin and Akcapinar, 1983; Khan and Sahni, 1983, Singh et al., 1983a; Singh et al., 1983b; Mavrogenis et al., 1984; Misra and Rawat, 1984; Nagpal and Chawla, 1984; Baik et al., 1985; Naik et al., 1985 and Malik et al., 1986). The heavier birth weight in male kids might be due to the effect of male sex hormone, which has an anabolic effect (Hafez, 1962).

The effect of month of birth on birth weight was highly significant ($P < 0.01$). Kids born in the months of February, March and April were heavier than those born in other months. Significant effect of month/season has also been reported earlier in Jamnapari and other breeds (Singh et al., 1977, Mittal, 1979, Singh et al., 1983b, Misra and Rawat, 1984; Nagpal and Chawla, 1984; Baik et al., 1985; Naik et al., 1985 and Malik et al. 1986). A few contrary reports are also available (Montaldo and Juarez, 1980 and Khan and Sahni, 1983). Heavier birth weight of the kids born in months of February-April might be due to the availability of good quality and quantity of feeds to their dams during pregnancy. Another reason might be that no physiological stress due to excessive heat or other unfavourable environmental conditions were imposed on the dams during their gestation period giving birth in the months of February-April.

The effect of interaction (type of birth x sex of kid) was not significant on birth weight. Present finding is similar to that of Mavrogenis et al. (1984) and Sarma et al. (1984). However, Barbieri et al. (1983) and Singh et al. (1983a) reported a significant interaction. Non-significant interaction probably indicated that the differences in birth weights due to type of birth were the same and/or common in both the sexes.

Effect of post-kidding weight of dam on birth weight was highly significant ($P < 0.01$) and heavier dams produced heavier kids. Present finding is in agreement with the findings of Prasad et al. (1971) in Barbari, Khan and Sahni (1983) in Jamnapari and Malik et al. (1986) in Beetal and Black Bengal goats. However, contrary reports are also available in the literature (Ayoadae and Butterworth, 1982 and Singh et al., 1983b). The significant effect of dam's weight at kidding on birth weight might be due to the reason that healthy dams could nourish their offspring in prenatal period better than the weak ones.

Correlation between birth weight and dam's weight at kidding was found positive and significant ($P < 0.05$). Similar finding was reported by Mittal (1979) and Mohd-Yusuf et al. (1981). It might be due to the reason that dams having higher body weight could nourish their foetus more effficiently than those having less body weight.

Heritability of birth weight could not be estimated since sire component of variance was negative. The estimates of heritability not significantly different from zero have also been reported by Guha et al. (1968) by regression of progenies on dams, Moulik and Syrstad (1970), Castillo et al. (1976) and Darokhan and Tomar (1983) by Paternal Half-sib Correlation method. A very low h^2 was reported by Madeli and Patro (1984). However, Montaldo and Juarez (1980) and Mavrogenis et al. (1984) have reported a high heritability for birth weight.

The negative sire variance component might be due to sampling error, selected group of sires, relationship among sires, confounding of sires within year and genotype x environment interaction etc. (Searle, 1961). If the h^2 of a trait is low such as birth weight, to have 95% chance of getting a non-negative estimate from sire component, at least 800 observations are needed provided the progeny size is large. If the information per sire in limited to less than 30-40 progenies, more than 800 observations are required for an estimate not to be affected by sampling fluctuation (Thompson and Moore, 1963 and Gill and Jonson, 1968). Since, the number of observations in present investigation was less, sampling error could be the reason for getting negative sire variance component. Therefore, to arrive at a valid conclusion large scale studies need to be conducted.

Correlation of Birth Weight with Subsequent Weights

The phenotypic correlation coefficients between birth weight and weights at subsequent ages i.e. from 1 month to 12 month of age at monthly interval were positive and highly significant upto 5 months of age and correlations of birth weight with 6 month weight and with subsequent weights were non-significant. Significant correlation of birth weight with 1 month weight has been reported by Dutta et al. (1963), Montemurro (1966), Ali (1980), Malik et al. (1986), with weaning weight by Mohd-Yusuf et al.(1981), Ayoadae and Butterworth (1982), Misra & Rawat (1984) and Malik et al. (1986). Present findings are in agreement with the above reports. Though there are few reports (Wijeratne, 1968 and Guha et al., 1968) that birth weight has significant correlation with yearling weight, but in present investigation correlations of birth weight with weight at 6 month and at subsequent ages were found to be non-significant. This finding is similar to the report of Madeli and Patro (1984). Significant correlations between birth weight and monthly body weights upto 5 months of age might be due to the reason that carry over effect of birth weight persisted upto 5 months of age. Moreover, kids having higher birth weight have more vigour than those born weaker.

SUMMARY

The objectives of the present investigation were to examine the effects of various factors (genetic and non-genetic) on birth weight and its correlation with subsequent weights. The investigation was carried out on 524 Jamnapari kids sired by 12 bucks and maintained at Central Institute for Research on Goats, Makhdoom, Mathura (UP) during 1982 to 1984. Least-squares technique was used to study the effects of year, month and type of birth, sire, sex of kid, interaction (type x sex) and dam's weight at kidding on birth weight. Sires were chosen at random, while the remaining effects were treated as fixed in the model.

Effects of year, type and month of birth, sex and dam's weight at kidding on birth weight were significant whereas, sire and interaction (type x sex) did not influence birth weight. The effect of year of birth was found to be significant on birth weight. Kids born in the year 1983 had highest birth weight followed by those born in 1982 and 1984, respectively. The type of birth also had highly significant effect on birth weight. Singles were heavier than twins and triplets. Male kids were significantly heavier than female indicating that sex had a significant effect on birth weight. Month of birth had significant effect on birth weight and kids born in the months of February and March were heavier than those born in other months.

Phenotypic correlation between dam's weight at kidding and birth weight (0.21) was found to be significant. Heritability of birth weight could not be estimated as the sire-variance component was negative. Phenotypic correlation coefficients between birth weight and weights at 1, 2, 3, 4 and 5 months were significant whereas with weights at 6 months and at subsequent ages were non-significant.

CONCLUSION

The present investigation was carried out with an objective to study birth weight and various genetic and non-genetic factors affecting it in Jamnapari goats.

Following conclusions were drawn from the results:-

1. Sire had no influence on birth weight and it is mainly affected by maternal effects.

2. Males had higher birth weight than females.

3. Singles had higher birth weight than twins, which were heavier than triplets.

4. Kids born in February-March had higher birth weight than those born in other months.

5. Heavier dams produced heavier kids.

6. Kids having higher birth weight tended to be heavier in later life also and carry-over effect of birth weight persisted upto 5 months of age.

7. Birth weight was positively and significantly correlated with weaning weight, hence, it could be a criterion to select animals for higher weaning weight.

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BODY WEIGHTS AND MEASUREMENTS

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BODY WEIGHTS AND MEASUREMENTS

Body weights and measurements are important traits for assessment of overall growth of an individual at different ages. The estimates of genetic and phenotypic parameters are very essential to decide upon the selection cirterion to get maximum market weight in a shorter time.

Measurements can also predict response in body weight (Darokhan and Tomar, 1983) since they are positively and significantly corelated (Tandon, 1966 and Bose and Basu, 1984). Correlation among body weights may be of use to select for heavier animals on the basis of their body weights in early life (Misra and Rawat, 1984). Body weight and body measurements at different ages are affected by year (Khan and Sahni, 1983), month (Misra and Rawat, 1984) and type of birth (Sarma et al., 1984), sex (Khan and Sahni, 1983), interaction of type with sex (Sarma et al., 1984) and dam's weight at kidding (Khan and Sahni, 1983).

The present investigation was taken up to find out the influence of various factors on body weights and measurements from birth to 12 months of age in Jamnapari goats and to determine relationship among body weights. Various genetic and phenotypic parameters were also calculated to find out the extent of variation (genetic and phenotypic) in body weights and measurements.

Data on weights and measurements from birth to 12 months of age and dam's weight at kidding on 524 kids sired by 12 bucks maintained at Central Institute for Research on Goats, Makhdoom, Mathura (UP) during 1982-84 were used in the present study.

Least-squares technique (Harvey, 1976) was used to examine the effect of various factors. Genetic and phenotypic parameters were estimated according to Becker (1964).

Averages

Averages, standard errors and coefficients of variation of body weights and body measurements (body length, height at withers and chest girth) for different factors are presented in Tables 2.1, 2.2, 2.3 and 2.4. Overall means of body weight at birth, 3, 6, 9 and 12 months averaged 3.35±0.03, 8.78±0.09, 12.75±0.13, 15.93±0.21 and 17.12±0.32 kg., respectively. Corresponding values for body length were 33.09±0.10, 46.28±0.18, 52.80±0.22, 57.90±0.31 and 59.90±0.36 cm., for height at withers 36.21±0.12, 48.50±0.18, 55.07±0.22, 59.90±0.29 and 61.90±0.36 cm. and for chest girth 32.31±0.12, 45.06±0.17, 50.82±0.20, 55.60±0.29 and 57.30±0.37 cm.

Least-squares Analysis

It was hypothesized a priori that body weights and body measurements at different ages were affected by year, type and month of birth, sex of kid, sire, interaction (type x sex) and dam's weight at kidding. Least-squares analyses of variance for these effects are presented in Tables 2.5.1, 2.5.2, 2.5.3 and 2.5.4.

The least-squares constants along with the standard errors of their corresponding least-squares mean are presented in Table 2.6. Results of Duncan's multiple range tests (modified by Kramer) are shown along with the constants.

Sire had a significant effect on weight at 1, 3, 4 and 6 months, on length at 2, 3, 4 and 5 months, on withers' height at 1, 2, 3, 4, 5, 6 and 9 months and on chest girth at 1, 4, 5, 6 and 9 months of age.

Year of birth had a significant effect on body weight at birth, 1, 2, 3, 8, 9 and 12 months, on length at 1, 2 and 3 months, on withers' height and chest girth at birth, 1, 2, 3, 4, 6 and 12 months of age. It was seen that kids born in the year 1983 were heavier than those born in other years, upto 3 months of age. Afterwards, kids born in 1982 were found to be heaviest in most cases. Kids born in 1982 were mostly having larger body measurements than others.

Type of birth had highly significant effect on body weight ($P < 0.01$) upto 6 months of age and significant effect ($P < 0.05$) on 7 month weight. Similarly, it affected all body measurements. The effect of type of birth on weight and measurements was found to be non-significant at 8 month and at subsequent ages. Single born kids were heavier and had larger body measurements than twins and triplets upto 7 months of age. Though statistically non-significant, singles were heavier and had larger body measurements than twins and triplets at 8, 9 and 10 months too and twins were heaviest and had larger body dimensions at 11 and 12 months of age.

Sex of kid had significant effect on body weights at all ages except at 2, 7, 8, 10 and 11 months, on all body measurements at birth, 1, 6, 9 and 12 months, on body length at 4 and 5 months and on chest girth at 3 months of age. Males were having higher body weight and larger body measurements than females at above ages, though statistically non-significant, similar trend was found at other ages too.

Month of birth had significant effect on body weights from birth to 6 and at 12 months of age, on all body measurements at birth, from 1 to 6 months, on length at 7, 8 and 9 months and on length and chest girth at 12 months of age. Mostly, the kids born in the months of February to April were heavier and had larger body dimensions than those born in other months.

Interaction (type of birth x sex) had no significant effect on weights and measurements at all ages.

Effect of dam's weight at kidding was found to be significant on body weights at birth, 1, 2 and 3 months and on all body measurements at birth, 1, 2, 3 and 4 months of age. Kids born out of heavy dam's were heavier and had larger body measurements than those born out of dams with less body weight.

Heritability

The estimates of heritabilities for body weights and body measurements are presented in Table 2.7. The estimates for body weights at birth, 10 and 11 months and body measurements at birth (except chest girth), 7, 8, 10 and 11 months of age could not be estimated because of the negative sire variance component. The estimates for body weights at 3, 6, 9 and 12 months were 0.257±0.152, 0.235±0.157, 0.176±0.171 and 0.237±0239. Due to large standard errors estimates for 9 and 12 months were not precise. Heritability was highest for length at 4 months (0.331±0.188), for height at 5 months (0.290±0.186) and for chest girth at 4 months (0.301±0.178) of age.

Correlations Among Body Weights

Phenotypic correlation coefficients along with the significance attached to them, are presented in Table 2.8. Birth weight was significantly ($P < 0.01$) correlated with weaning weight (0.27), but not with subsequent weights. Weaning weight had significant correlation with 6 (0.70), 9 (0.52) and 12 (0.53) months of weight. Six month weight had significant correlation with 9 (0.76) and 12 (0.67) month weights and so also 9 month weight with 12 month weight (0.81).

Regression of Weight on Age

Regression of body weight (in kg.) on age (in months) were determined for different factors and tested for their significance. The estimates are presented in Table 2.9. All the regression coefficients were found to be positive and significant. Males grew faster (b=1.415 kg./month) than females (b=1.305 kg./month). Twin born kids had highest growth rate (b=1.412 kg./month) among all types and so also kids born in 1982 (b=1.562 kg./month) as compared to those born in 1983 and 1984. Kids born in the months of September-October (b=1.5 kg./month) had higher growth rate than those born in February-April (b=1.3 kg./month) and November-December (b=1.2 kg./month).

Table 2.1 : Mean Values of Body Weights, Their Standard Errors and Coefficients of Variation At Different Ages in Jamnapari Goats

	Age		Overall	Sex		Type of Birth		
				Male	Female	Single	Twin	Triplet
1.	At Birth	No.	524	258	266	226	281	17
		Mean	3.354	3.559	3.154	3.669	3.126	2.923
		SE	0.032	0.045	0.042	0.046	0.039	0.198
		CV	21.729	20.212	21.625	18.869	20.851	27.986
2.	At 1 Month	No.	437	211	226	197	225	15
		Mean	5.339	5.563	5.130	5.692	5.069	4.760
		SE	0.050	0.077	0.062	0.075	0.062	0.318
		CV	19.659	20.023	18.348	18.597	18.336	25.910
3.	At 2 Months	No.	418	204	214	191	214	13
		Mean	7.152	7.450	6.868	7.531	6.822	7.008
		SE	0.069	0.104	0.087	0.096	0.094	0.513
		CV	19.765	20.013	18.572	17.710	20.166	26.419
4.	At 3 Months	No.	390	186	204	183	195	12
		Mean	8.730	9.145	8.351	9.054	8.436	8.567
		SE	0.092	0.142	0.114	0.126	0.135	0.569
		CV	20.932	21.217	19.549	18.862	22.339	23.017

Contd.

Table 2.1 : Contd.

	Age		Overall	Sex		Type of Birth		
				Male	Female	Single	Twin	Triplet
5.	At 4 Months	No.	321	152	169	156	154	11
		Mean	9.726	10.202	9.297	9.977	9.463	9.845
		SE	0.110	0.170	0.137	0.154	0.165	0.486
		CV	20.431	20.559	10.172	19.329	21.622	16.373
6.	At 5 Months	No.	273	132	141	127	135	11
		Mean	11.016	11.577	10.491	11.586	10.495	10.836
		SE	0.137	0.214	0.162	0.193	0.196	0.404
		CV	20.536	21.234	18.372	18.848	21.703	12.362
7.	At 6 Months	No.	313	149	164	158	144	11
		Mean	12.758	13.529	12.058	13.064	12.464	12.227
		SE	0.135	0.201	0.163	0.189	0.201	0.469
		CV	18.669	18.132	13.313	18.149	19.363	12.744
8.	At 7 Months	No.	170	76	94	87	75	8
		Mean	13.831	14.535	13.262	14.444	13.222	12.875
		SE	0.206	0.356	0.221	0.283	0.311	0.474
		CV	19.412	21.359	16.161	18.298	20.378	10.410
9.	At 8 Months	No.	120	64	56	66	48	6
		Mean	15.160	15.987	14.216	15.842	14.373	13.967
		SE	0.291	0.448	0.316	0.405	0.433	0.701
		CV	21.038	22.427	16.619	20.785	20.851	12.291

Contd.

Table 2.1 : Contd.

Age			Overall	Sex		Type of Birth		
				Male	Female	Single	Twin	Triplet
10.	At 9 Months	No.	211	110	101	115	88	8
		Mean	15.932	16.981	14.789	16.249	15.504	16.062
		SE	0.214	0.316	0.241	0.302	0.321	0.667
		CV	19.558	19.527	16.390	19.947	19.416	11.760
11.	At 10 Months	No.	95	42	53	52	37	6
		Mean	16.945	17.731	16.323	17.144	16.729	16.550
		SE	0.345	0.596	0.384	0.494	0.543	0.809
		CV	19.870	21.790	17.145	20.791	19.759	11.974
12.	At 11 Months	No.	69	34	35	36	28	5
		Mean	17.21	18.479	15.834	16.921	17.317	17.971
		SE	0.409	0.636	0.468	0.489	0.789	0.733
		CV	18.497	19.085	15.919	15.912	22.598	9.356
13.	At 12 Months	No.	148	72	76	85	56	7
		Mean	18.421	19.444	17.389	18.464	18.479	17.520
		SE	0.319	0.469	0.381	0.399	0.583	0.548
		CV	22.663	21.545	20.998	21.774	25.226	8.068

Table 2.2 : Mean Values of Body Lengths With Their Standard Errors and Coefficients of Variation At Different Ages in Jamnapari Goats

Age			Overall	Sex		Type of Birth		
				Male	Female	Single	Twin	Triplet
1.	At Birth	No.	524	258	266	226	281	17
		Mean	33.09	33.55	32.66	33.75	32.69	31.00
		SE	0.10	0.14	0.15	0.15	0.14	0.60
		CV	7.23	6.53	7.67	6.58	7.25	7.98
2.	At 1 Month	No.	437	211	226	197	225	15
		Mean	39.78	40.32	39.28	40.85	38.91	38.93
		SE	0.14	0.21	0.19	0.19	0.19	0.84
		CV	7.46	7.55	7.16	6.76	7.28	8.32
3.	At 2 Months	No.	418	204	214	191	214	13
		Mean	43.47	43.96	43.00	44.42	42.62	43.61
		SE	0.15	0.23	0.19	0.20	0.21	1.16
		CV	7.16	7.39	6.76	6.42	7.11	9.62
4.	At 3 Months	No.	390	186	204	183	195	12
		Mean	46.28	47.07	45.57	47.14	45.45	46.75
		SE	0.18	0.27	0.22	0.23	0.26	1.21
		CV	7.55	7.90	6.84	6.59	7.95	8.94

Contd.

Table 2.2 : Contd.

	Age		Overall	Sex		Type of Birth		
				Male	Female	Single	Twin	Triplet
5.	At 4 Months	No.	321	152	169	156	154	11
		Mean	47.96	48.88	47.14	48.69	47.19	48.45
		SE	0.20	0.31	0.26	0.27	0.31	1.09
		CV	7.71	7.75	7.28	7.07	8.10	7.52
6.	At 5 Months	No.	273	132	141	127	135	11
		Mean	50.34	51.36	49.39	51.42	49.31	50.64
		SE	0.22	0.33	0.28	0.32	0.31	0.56
		CV	7.33	7.39	6.75	6.95	7.37	3.67
7.	At 6 Months	No.	313	149	164	158	144	11
		Mean	52.80	53.97	51.74	53.48	52.10	52.00
		SE	0.22	0.30	0.29	0.30	0.33	0.62
		CV	7.38	6.95	7.21	7.23	7.53	3.94
8.	At 7 Months	No.	170	76	94	87	75	8
		Mean	54.10	55.40	52.90	55.00	53.00	53.00
		SE	0.31	0.49	0.34	0.43	0.43	0.73
		CV	7.39	7.77	6.37	7.42	7.15	3.91
9.	At 8 Months	No.	120	64	56	66	48	6
		Mean	55.80	57.00	54.40	56.60	54.80	54.80
		SE	0.41	0.59	0.53	0.60	0.57	1.01
		CV	8.12	8.24	7.23	8.67	7.26	4.53

Contd.

Table 2.2 : Contd.

Age			Overall	Sex		Type of Birth		
				Male	Female	Single	Twin	Triplet
10.	At 9 Months	No.	211	110	101	115	88	8
		Mean	57.90	59.20	56.60	58.40	57.56	57.40
		SE	0.31	0.45	0.38	0.44	0.47	1.18
		CV	7.82	8.02	6.82	8.05	7.66	5.81
11.	At 10 Months	No.	95	42	53	52	37	6
		Mean	58.20	59.20	57.40	58.50	57.80	58.20
		SE	0.46	0.77	0.54	0.69	0.67	1.11
		CV	7.71	8.43	6.84	8.49	7.02	4.67
12.	At 11 Months	No.	69	34	35	36	28	5
		Mean	59.90	61.30	58.50	59.70	60.10	60.00
		SE	0.52	0.79	0.63	0.76	0.83	0.89
		CV	7.18	7.59	6.37	7.59	7.30	3.33
13.	At 12 Months	No.	148	72	76	85	56	7
		Mean	60.20	61.60	59.20	60.40	60.20	60.60
		SE	0.36	0.49	0.48	0.50	0.58	0.61
		CV	7.40	6.79	7.11	7.78	7.28	2.67

Table 2.3 : Mean Values of Body Heights With Their Standard Errors and Coefficients of Variation At Different Ages in Jamnapari Goats

	Age		Overall	Sex		Type of Birth		
				Male	Female	Single	Twin	Triplet
1.	At Birth	No.	524	258	266	226	281	17
		Mean	36.21	36.75	35.69	37.07	35.66	33.76
		SE	0.12	0.15	0.17	0.17	0.15	0.60
		CV	7.36	6.77	7.65	6.89	7.09	7.37
2.	At 1 Month	No.	437	211	226	197	225	15
		Mean	42.23	42.71	41.78	43.21	41.42	41.47
		SE	0.13	0.18	0.17	0.20	0.17	0.83
		CV	6.37	6.27	6.29	5.69	6.19	7.73
3.	At 2 Months	No.	418	204	214	191	214	13
		Mean	45.62	46.17	45.09	46.61	44.72	45.92
		SE	0.15	0.23	0.20	0.21	0.21	1.16
		CV	6.94	7.09	6.59	6.10	6.98	9.08
4.	At 3 Months	No.	390	186	204	183	195	12
		Mean	48.50	49.28	47.78	49.36	47.69	48.58
		SE	0.18	0.26	0.23	0.24	0.25	1.25
		CV	7.29	7.33	6.94	6.63	7.46	8.88

Contd.

Table 2.3 : Contd.

	Age		Overall	Sex		Type of Birth		
				Male	Female	Single	Twin	Triplet
5.	At 4 Months	No.	321	152	169	156	154	11
		Mean	50.05	50.92	49.27	50.79	49.29	50.09
		SE	0.20	0.30	0.26	0.26	0.30	1.09
		CV	7.19	7.27	6.77	6.51	7.61	7.22
6.	At 5 Months	No.	273	132	141	127	135	11
		Mean	52.34	53.18	51.55	53.35	51.40	52.18
		SE	0.23	0.36	0.29	0.32	0.34	0.88
		CV	7.39	7.70	6.73	6.79	7.66	5.61
7.	At 6 Months	No.	313	149	164	158	144	11
		Mean	55.07	56.17	54.08	55.63	54.48	54.91
		SE	0.22	0.33	0.28	0.30	0.33	0.96
		CV	7.10	7.11	6.58	6.93	7.26	5.84
8.	At 7 Months	No.	170	76	94	87	75	8
		Mean	56.40	57.50	55.50	57.30	55.40	55.50
		SE	0.30	0.48	0.36	0.41	0.45	0.98
		CV	7.01	7.35	6.27	6.75	7.07	5.00
9.	At 8 Months	No.	120	64	56	66	48	6
		Mean	58.00	59.30	56.50	58.90	57.00	56.50
		SE	0.37	0.52	0.44	0.51	0.55	1.09
		CV	6.96	7.07	5.89	7.00	6.73	4.72

Contd.

Table 2.3 : Contd.

Age			Overall	Sex		Type of Birth		
				Male	Female	Single	Twin	Triplet
10.	At 9 Months	No.	211	110	101	115	88	8
		Mean	59.90	61.20	58.40	60.30	59.30	59.20
		SE	0.29	0.40	0.37	0.39	0.45	1.15
		CV	7.04	6.86	6.39	6.99	7.17	5.47
11.	At 10 Months	No.	95	42	53	52	37	6
		Mean	60.50	61.40	59.80	60.80	60.30	59.20
		SE	0.42	0.73	0.46	0.57	0.71	0.95
		CV	6.76	7.72	5.65	6.76	7.13	3.91
12.	At 11 Months	No.	69	34	35	36	28	5
		Mean	62.10	63.30	60.80	62.30	62.10	60.00
		SE	0.48	0.74	0.55	0.61	0.88	0.84
		CV	6.44	6.83	5.38	5.84	7.51	3.12
13.	At 12 Months	No.	148	72	76	85	56	7
		Mean	61.90	63.70	60.40	61.90	62.20	61.80
		SE	0.36	0.49	0.44	0.45	0.64	0.79
		CV	6.98	6.50	6.41	6.69	7.75	3.42

Table 2.4 : Mean Values of Chest Girth With Their Standard Errors and Coefficients of Variation At Different Ages in Jamnapari Goats

	Age		Overall	Sex		Type of Birth		
				Male	Female	Single	Twin	Triplet
1.	At Birth	No.	524	258	266	226	281	17
		Mean	32.31	32.76	31.88	33.25	31.64	31.00
		SE	0.12	0.15	0.18	0.18	0.15	0.66
		CV	8.62	7.47	9.47	8.28	8.19	8.76
2.	At 1 Month	No.	437	211	226	197	225	15
		Mean	38.14	38.56	37.75	39.32	37.23	36.47
		SE	0.14	0.21	0.19	0.20	0.18	0.61
		CV	7.83	7.75	7.79	7.25	7.43	6.54
3.	At 2 Months	No.	418	204	214	191	214	13
		Mean	42.00	42.53	41.49	43.00	41.12	41.84
		SE	0.15	0.24	0.19	0.21	0.20	1.12
		CV	7.51	7.95	6.84	6.91	7.29	9.65
4.	At 3 Months	No.	390	186	204	183	195	12
		Mean	45.06	45.76	44.41	45.85	44.29	45.42
		SE	0.17	0.25	0.22	0.22	0.25	1.07
		CV	7.48	7.50	7.18	6.42	8.04	8.15

Contd.

Table 2.4 : Contd.

Age			Overall	Sex		Type of Birth		
				Male	Female	Single	Twin	Triplet
5.	At 4 Months	No.	321	152	169	156	154	11
		Mean	46.55	47.23	45.95	47.29	45.75	47.36
		SE	0.19	0.27	0.27	0.26	0.28	0.96
		CV	7.46	7.07	7.59	6.87	7.77	6.76
6.	At 5 Months	No.	273	132	141	127	135	11
		Mean	48.76	49.64	47.94	49.77	47.80	49.00
		SE	0.22	0.34	0.28	0.30	0.32	0.81
		CV	7.57	7.78	6.94	6.83	7.92	5.47
7.	At 6 Months	No.	313	149	164	158	144	11
		Mean	50.82	51.97	49.77	51.39	50.22	50.36
		SE	0.20	0.30	0.25	0.28	0.30	0.81
		CV	7.10	7.07	6.47	6.98	7.19	5.34
8.	At 7 Months	No.	170	76	94	87	75	8
		Mean	52.60	53.70	51.70	53.40	51.80	51.10
		SE	0.28	0.47	0.32	0.37	0.44	0.81
		CV	7.00	7.58	5.99	6.46	7.47	4.49
9.	At 8 Months	No.	120	64	56	66	48	6
		Mean	54.30	55.30	53.20	55.30	53.20	52.70
		SE	0.39	0.59	0.46	0.52	0.59	1.26
		CV	7.84	8.59	6.44	7.68	7.75	5.84

Contd.

Table 2.4 : Contd.

Age			Overall	Sex		Type of Birth		
				Male	Female	Single	Twin	Triplet
10.	At 9 Months	No.	211	110	101	115	88	8
		Mean	55.60	56.80	54.30	56.10	54.90	55.50
		SE	0.29	0.42	0.35	0.40	0.43	1.25
		CV	7.52	7.74	6.44	7.69	7.32	6.39
11.	At 10 Months	No.	95	42	53	52	37	6
		Mean	56.40	57.20	55.70	56.80	55.90	55.60
		SE	0.41	0.69	0.48	0.57	0.65	1.08
		CV	7.09	7.88	6.18	7.31	7.09	4.77
12.	At 11 Months	No.	69	34	35	36	28	5
		Mean	57.30	58.80	55.80	56.90	57.60	57.40
		SE	0.46	0.70	0.57	0.59	0.84	0.81
		CV	6.58	6.90	5.86	6.11	7.64	3.16
13.	At 12 Months	No.	148	72	76	85	56	7
		Mean	54.40	59.40	57.40	58.60	58.30	59.10
		SE	0.37	0.48	0.49	0.48	0.61	0.83
		CV	7.77	7.02	7.69	7.89	7.92	3.71

Table 2.5.1 : Least-squares Analysis of Variance for Various Factors Affecting Body Weights at Different Ages in Jamnapari Goats

Source of Variation	d.f.	M.S.				
		At Birth	1 Month	2 Month	3 Month	4 Month
Sire	11	0.188	1.058*	2.040	5.832**	8.854**
Year of Birth	2	11.469**	22.807**	16.854**	11.909**	3.393
Type of Birth	2	23.332**	27.845**	32.685**	28.077**	16.195**
Sex	1	3.489**	3.872**	2.026	10.825*	13.627*
Month of Birth	7	6.462**	18.099**	33.768**	57.961**	39.376**
Type of Birth x Sex	2	0.113	0.883	2.199	1.263	0.044
<u>Regression</u>						
Dam's Weight at Kidding	1	26.448**	10.906**	14.977**	11.561*	9.232
Error	497	0.262	0.575	1.089	1.898	2.493
			(410)	(391)	(363)	(294)

Contd.

Table 2.5.1 : Contd.

Source of Variation	d.f.	M.S.			
		5 Month	6 Month Φ	7 Month §	8 Month §
Sire	11	9.858	11.454*	6.606	9.547
Year of Birth	2	1.977	13.023	18.243	29.251*
Type of Birth	2	33.803**	22.809**	29.793*	13.863
Sex	1	18.445*	41.587**	4.115	3.328
Month of Birth	7	15.399**	15.249**	3.725	5.193
Type of Birth x Sex	2	2.048	0.322	1.028	5.574
Regression					
Dam's Weight at Kidding	1	7.147	8.998	0.017	0.803
Error	246	3.999	4.584	6.591	9.116
			(287)	(145)	(95)

Contd.

Table 2.5.1 : Contd.

Source of Variation	d.f.	M.S.			
		9 Month	10 Month §Ψ	11 Month §Ψ	12 Month §Ψ
Sire	11	14.011	7.788	8.024	12.893
Year of Birth	1	69.679**	16.512	34.417	246.661**
Type of Birth	2	7.027	1.983	10.413	4.224
Sex	1	49.445*	0.644	8.627	81.320**
Month of Birth	5	2.337	7.867	14.341	46.450**
Type of Birth x Sex	2	0.776	10.387	6.957	1.066
<u>Regression</u>					
Dam's Weight at Kidding	1	0.262	3.502	1.098	0.387
Error	187	8.054	11.242	10.233	7.617
			(71)	(45)	(124)

*Significant at $P < 0.05$, **Significant at $P < 0.01$

Figures in parentheses are error degrees of freedom

Φ — 6 d.f. for month of birth, § — 5 d.f. for month of birth and Ψ — 1 d.f. for year of birth

Table 2.5.2 : Least-squares Analysis of Variance for Various Factors Affecting Body Length at Different Ages in Jamnapari Goats

Source of Variation	d.f.	M.S.				
		At Birth	1 Month	2 Month	3 Month	4 Month
Sire	11	3.015	7.515	12.600**	16.108**	25.083**
Year of Birth	2	9.137	180.041**	157.683**	44.069**	10.904
Type of Birth	2	184.637**	194.905**	138.278**	143.002**	103.361**
Sex	1	32.297**	20.624*	0.144	10.097	34.315*
Month of Birth	7	39.523**	123.111**	142.701**	180.113**	148.996**
Type of Birth x Sex	2	0.452	2.753	10.811	16.197	0.727
Regression						
Dam's Weight at Kidding	1	254.276**	101.386**	75.201**	59.298**	66.509**
Error	497	4.108	4.582	4.967	6.993	7.795
			(410)	(391)	(363)	(294)

Contd.

Table 2.5.2 : Contd.

Source of Variation	d.f.	M.S.			
		5 Month	6 Month $^{\Phi}$	7 Month §	8 Month §
Sire	11	22.673**	20.721	7.876	8.395
Year of Birth	2	10.150	11.897	2.356	13.082
Type of Birth	2	99.864**	81.360**	61.826*	31.220
Sex	1	40.260*	60.093*	26.897	13.468
Month of Birth	7	56.816**	66.845**	48.896**	52.230**
Type of Birth x Sex	2	11.573	1.401	0.079	6.784
<u>Regression</u>					
Dam's Weight at Kidding	1	17.238	17.794	1.739	5.958
Error	246	9.729	11.606	12.599	16.092
			(287)	(145)	(95)

Contd.

Table 2.5.2 : Contd.

Source of Variation	d.f.	M.S.			
		9 Month	10 Month § Ψ	11 Month § Ψ	12 Month § Ψ
Sire	11	24.146	14.338	13.037	18.243
Year of Birth	1	48.123	8.643	0.019	247.739**
Type of Birth	2	28.398	8.956	1.697	2.594
Sex	1	80.129*	0.408	3.131	63.133*
Month of Birth	5	90.987**	37.259	21.832	59.384**
Type of Birth x Sex	2	0.364	9.523	10.305	7.255
Regression					
Dam's Weight at Kidding	1	1.572	0.634	6.367	8.873
Error	187	16.475	18.405 (71)	18.645 (45)	14.253 (124)

*Significant at $P < 0.05$, **Significant at $P < 0.01$

Figures in parentheses are error degrees of freedom

Φ — 6 d.f. for month of birth, § — 5 d.f. for month of birth and Ψ — 1 d.f. for year of birth

Table 2.5.3 : Least-squares Analysis of Variance for Various Factors Affecting Withers' Height at Different Ages in Jamnapari Goats

Source of Variation	d.f.	M.S.				
		At Birth	1 Month	2 Month	3 Month	4 Month
Sire	11	1.817	13.409**	16.809**	22.083*	20.902**
Year of Birth	2	15.346*	71.763**	171.839**	126.816**	29.552*
Type of Birth	2	284.058**	192.835**	158.178**	133.491**	104.684**
Sex	1	54.202**	16.286*	13.107	14.913	21.673
Month of Birth	7	66.754**	83.613**	162.679**	197.943**	131.058**
Type of Birth x Sex	2	1.295	2.053	1.543	6.725	2.399
<u>Regression</u>						
Dam's Weight at Kidding	1	334.450**	96.225**	91.737**	50.190*	53.966*
Error	497	4.491	4.174	5.294	7.171	8.187
			(410)	(391)	(363)	(294)

Contd.

Table 2.5.3 : Contd.

Source of Variation	d.f.	M.S.			
		5 Month	6 Month $^{\Phi}$	7 Month §	8 Month §
Sire	11	28.276**	28.498*	13.731	13.007
Year of Birth	2	28.664	45.271*	12.490	7.594
Type of Birth	2	95.035**	62.789**	64.999*	20.743
Sex	1	16.225	85.576**	9.077	25.106
Month of Birth	7	69.038**	34.187*	17.414	16.478
Type of Birth x Sex	2	12.164	2.120	1.658	0.630
Regression					
Dam's Weight at Kidding	1	17.197	23.393	0.182	0.541
Error	246	10.865	12.732	13.737	14.554
			(287)	(145)	(95)

Contd.

Table 2.5.3 : Contd.

Source of Variation	d.f.	M.S.			
		9 Month	10 Month §Ψ	11 Month §Ψ	12 Month §Ψ
Sire	11	30.693	12.777	10.644	19.078
Year of Birth	1	16.082	3.965	0.001	227.875**
Type of Birth	2	24.811	13.150	5.816	5.181
Sex	1	110.136**	5.564	14.635	174.266**
Month of Birth	5	24.315	8.711	11.343	32.325
Type of Birth x Sex	2	0.599	4.649	5.702	18.592
Regression					
Dam's Weight at Kidding	1	0.492	1.084	10.120	0.031
Error	187	15.004	17.520 (71)	16.974 (45)	14.342 (124)

*Significant at $P < 0.05$, **Significant at $P < 0.01$

Figures in parentheses are error degrees of freedom

Φ — 6 d.f. for month of birth, § — 5 d.f. for month of birth and Ψ — 1 d.f. for year of birth

Table 2.5.4 : Least-squares Analysis of Variance for Various Factors Affecting Chest Girth at Different Ages in Jamnapari Goats

Source of Variation	d.f.	M.S.				
		At Birth	1 Month	2 Month	3 Month	4 Month
Sire	11	5.684	8.785*	9.066	11.439	21.488**
Year of Birth	2	72.108**	140.407**	155.478**	65.019**	33.345*
Type of Birth	2	258.241**	243.213**	150.585**	107.179**	97.945**
Sex	1	28.161*	22.687*	0.863	26.345*	12.070
Month of Birth	7	112.415**	124.916**	119.030**	157.106**	121.685**
Type of Birth x Sex	2	2.217	7.211	8.889	4.585	0.710
<u>Regression</u>						
Dam's Weight at Kidding	1	266.389**	72.334**	101.734**	59.558*	68.285**
Error	497	4.796	4.473	5.268	6.783	7.159
			(410)	(391)	(363)	(294)

Contd.

Table 2.5.4 : Contd.

Source of Variation	d.f.	M.S. 5 Month	M.S. 6 Month $^{\Phi}$	M.S. 7 Month §	M.S. 8 Month §
Sire	11	22.409**	29.363**	6.372	11.523
Year of Birth	2	27.508	30.954	3.731	38.150
Type of Birth	2	94.213**	62.574**	46.549*	34.886
Sex	1	25.802	83.921**	13.901	3.207
Month of Birth	7	56.288**	30.895*	21.522	27.245
Type of Birth x Sex	2	2.069	2.146	0.290	8.811
<u>Regression</u>					
Dam's Weight at Kidding	1	15.389	25.840	2.145	7.724
Error	246	9.785	10.158	12.240	15.293
			(287)	(145)	(95)

Contd.

Table 2.5.4 : Contd.

Source of Variation	d.f.	M.S.			
		9 Month	10 Month § Ψ	11 Month § Ψ	12 Month § Ψ
Sire	11	31.899^{*}	10.213	8.631	22.874
Year of Birth	1	19.506	4.457	0.348	333.161^{**}
Type of Birth	2	26.360	16.061	1.606	2.002
Sex	1	124.919^{**}	1.204	5.489	162.519^{**}
Month of Birth	5	11.025	14.507	6.021	47.173^{**}
Type of Birth x Sex	2	5.995	4.187	4.770	7.465
Regression					
Dam's Weight at Kidding	1	0.011	0.010	5.126	5.856
Error	187	14.753	16.399 (71)	16.751 (45)	13.333 (124)

*Significant at $P < 0.05$, **Significant at $P < 0.01$

Figures in parentheses are error degrees of freedom

Φ — 6 d.f. for month of birth, § — 5 d.f. for month of birth and Ψ — 1 d.f. for year of birth

Table 2.6 : Least Square Constants and Standard Errors of Their Corresponding Least-squares Means for Various Factors Affecting Body Weights [in Kg.] & Body Measurements [in cm.] at Different Ages in Jamnapari Goats

AT BIRTH

Factors	Body Weight	Body Length	Withers' Height	Chest Girth
u	3.129±0.060	32.215±0.237	34.929±0.248	32.071±0.285
Year of birth				
1982	0.100±0.097[b]	-0.468±0.387[b]	-0.607±0.405[b]	1.266±0.436[a]
1983	0.357±0.070[a]	-0.107±0.279[ab]	-0.139±0.292[b]	0.359±0.326[b]
1984	-0.457±0.083[c]	0.575±0.327[a]	0.746±0.342[a]	-1.626±0.374[c]
Type of birth				
Single	0.537±0.053[a]	1.687±0.210[a]	2.085±0.220[a]	1.740±0.258[a]
Twin	-0.074±0.050[b]	0.107±0.198[b]	0.118±0.207[b]	-0.319±0.247[b]
Triplet	-0.462±0.135[c]	-1.794±0.537[c]	-2.204±0.561[c]	-1.422±0.594[b]
Sex				
Male	0.164±0.079	0.500±0.315	0.648±0.330	0.467±0.362
Female	-0.164±0.070	-0.500±0.278	0.648±0.291	-0.467±0.325
Month of Birth				
February	0.397±0.146[ab]	-0.609±0.578[bc]	0.302±0.605[ab]	1.100±0.637[ab]
March	0.485±0.071[a]	0.493±0.280[ab]	0.932±0.290[a]	1.775±0.327[a]
April	0.185±0.211[abc]	-0.047±0.836[abc]	-1.004±0.875[b]	1.142±0.912[ab]
May	0.069±0.126[bc]	-1.171±0.500[c]	-1.227±0.523[b]	-0.403±0.554[b]
September	-0.549±0.073[d]	-0.937±0.289[c]	-0.875±303[b]	-2.604±0.336[c]
October	-0.219±0.190[cd]	0.911±0.754[ab]	0.241±0.788[ab]	-0.419±0.824[ab]
November	-0.389±0.081[d]	0.289±0.320[ab]	-0.022±0.335[ab]	-0.393±0.368[b]
December	0.021±0.071[c]	1.069±0.281[a]	1.651±0.294[a]	-0.199±0.328[b]
Type of Birth x Sex				
Single male	-0.004±0.062	-0.091±0.248	-0.137±0.259	-0.180±0.295
Single female	0.004±0.064	0.091±0.254	0.137±0.266	0.180±0.301
Twin male	0.035±0.060	-0.049±0.240	-0.134±0.251	-0.019±0.287
Twin female	-0.035±0.057	0.049±0.226	0.134±0.236	0.019±0.273
Triplet male	-0.031±0.201	0.141±0.796	0.271±0.832	0.199±0.869
Triplet female	0.031±0.169	-0.141±0.671	-0.271±0.701	-0.199±0.735
Regression				
Dam's weight at kidding	0.036±0.004	0.113±0.014	0.129±0.015	0.115±0.015

Table 2.6 : Contd.

AT FIRST MONTH

Factors	Body Weight	Body Length	Withers' Height	Chest Girth
u	5.369±0.133	40.066±0.352	42.231±0.485	38.199±0.385
Year of birth				
1982	0.762±0.187[a]	2.455±0.511[a]	1.636±0.600[a]	2.226±0.531[a]
1983	0.392±0.149[b]	0.788±0.400[b]	0.368±0.518[b]	0.617±0.428[b]
1984	-1.154±0.173[c]	-3.243±0.471[c]	-2.005±0.570[c]	-2.843±0.494[c]
Type of birth				
Single	0.669±0.126[a]	1.580±0.333[a]	1.574±0.472[a]	1.929±0.368[a]
Twin	-0.019±0.124[b]	-0.372±0.327[b]	-0.366±0.469[b]	-0.148±0.362[b]
Triplet	-0.650±0.231[c]	-1.208±0.641[b]	-1.208±0.705[b]	-1.781±0.654[c]
Sex				
Male	0.183±0.153	0.423±0.413	0.376±0.528	0.443±0.440
Female	-0.183±0.147	-0.423±0.395	-0.376±0.514	-0.443±0.425
Month of Birth				
February	1.353±0.255[a]	4.189±0.706[a]	3.417±0.760[a]	3.325±0.717[a]
March	0.883±0.158[b]	2.102±0.427[b]	1.852±0.537[b]	1.805±0.452[b]
April	0.455±0.335[bc]	0.498±0.937[bc]	-0.708±0.961[cd]	0.042±0.940[c]
May	0.419±0.243[c]	0.256±0.674[c]	-0.818±0.732[cd]	-0.106±0.686[c]
September	-1.382±0.154[f]	-3.340±0.416[d]	-2.251±0.529[d]	-3.445±0.442[d]
October	-0.625±0.304[de]	-1.610±0.847[c]	-0.020±0.881[c]	-0.175±0.852[c]
November	-0.357±0.165[d]	-0.695±0.447[c]	-0.521±0.551[c]	-0.342±0.471[c]
December	0.747±0.152[e]	-1.400±0.409[c]	-0.943±0.542[cd]	-1.105±0.436[c]
Type of Birth x Sex				
Single male	-0.025±0.138	0.010±0.367	0.058±0.459	-0.267±0.398
Single female	0.025±0.138	-0.010±0.368	-0.058±0.496	0.267±0.399
Twin male	0.100±0.138	0.209±0.366	0.198±0.495	0.105±0.397
Twin female	-0.100±0.132	-0.209±0.349	0.198±0.483	-0.105±0.382
Triplet male	-0.075±0.314	-0.219±0.876	-0.256±0.907	0.163±0.881
Triplet female	0.075±0.296	0.219±0.825	0.256±0.862	-0.163±0.832
Regression				
Dam's weight at kidding	0.026±0.005	0.079±0.017	0.077±0.016	0.067±0.017

Contd.

Table 2.6 : Contd.

AT 2 MONTH

Factors	Body Weight	Body Length	Withers' Height	Chest Girth
u	7.078±0.196	43.716±0.497	45.664±0.578	42.093±0.413
Year of birth				
1982	0.515±0.273[a]	2.421±0.640[a]	1.387±0.713[a]	2.495±0.586[a]
1983	0.441±0.271[a]	0.711±0.534[b]	1.517±0.613[a]	0.577±0.459[b]
1984	-0.956±0.254[b]	-3.132±0.602[c]	-2.905±0.677[b]	-3.072±0.542[c]
Type of birth				
Single	0.670±0.186[a]	1.263±0.477[a]	1.294±0.560[a]	1.381±0.388[a]
Twin	-0.149±0.183[b]	-0.463±0.472[b]	-0.568±0.556[b]	-0.399±0.381[b]
Triplet	-0.521±0.349[b]	-0.801±0.791[b]	-0.725±0.859[b]	-0.981±0.757[b]
Sex				
Male	0.145±0.234	0.039±0.567	0.369±0.643	0.095±0.500
Female	-0.145±0.212	-0.039±0.524	-0.369±0.604	-0.095±0.448
Month of Birth				
February	1.435±0.357[b]	3.944±0.807[a]	3.752±0.875[a]	3.152±0.775[a]
March	1.488±0.230[a]	2.193±0.558[b]	2.289±0.635[b]	2.015±0.489[a]
April	0.214±0.467[c]	0.374±1.032[c]	0.227±1.099[c]	-0.405±1.019[b]
May	0.056±0.347[c]	-1.632±0.787[cd]	-1.107±0.855[c]	-0.688±0.752[b]
September	-1.675±0.244[d]	-0.039±0.547[d]	-3.571±0.625[d]	-2.909±0.476[c]
October	-0.920±0.446[cd]	-0.976±0.989[c]	-0.603±1.056[c]	-0.907±0.973[b]
November	-0.010±0.242[c]	-0.011±0.580[c]	-0.182±0.656[c]	-0.054±0.576[b]
December	-0.248±0.227[c]	-0.852±0.551[c]	-0.804±0.629[c]	-0.202±0.481[b]
Type of Birth x Sex				
Single male	0.079±0.200	0.355±0.503	0.192±0.585	0.337±0.421
Single female	-0.079±0.203	-0.355±0.507	-0.192±0.588	-0.337±0.426
Twin male	0.224±0.200	0.508±0.503	0.083±0.584	0.457±0.421
Twin female	-0.224±0.194	-0.508±0.492	-0.083±0.574	-0.457±0.407
Triplet male	-0.303±0.507	-0.864±1.114	-0.275±1.182	-0.795±1.107
Triplet female	0.303±0.411	0.864±0.917	0.275±0.984	0.795±0.895
Regression				
Dam's weight at kidding	0.031±0.008	0.069±0.018	0.077±0.018	0.081±0.018

Contd.

AT 3 MONTH

Factors	Body Weight	Body Length	Withers' Height	Chest Girth
u	8.346±0.351	45.955±0.577	47.738±0.683	44.911±0.478
Year of birth				
1982	-0.118±0.434^{b}	0.896±0.757^{a}	0.177±0.845^{b}	1.338±0.680^{a}
1983	0.474±0.372^{a}	0.693±0.624^{a}	1.539±0.724^{a}	0.691±0.532^{a}
1984	-0.356±0.413^{a}	-1.589±0.711^{b}	-1.717±0.803^{c}	-2.030±0.636^{b}
Type of birth				
Single	0.661±0.341^{a}	1.179±0.555^{a}	1.301±0.664^{a}	1.022±0.452^{a}
Twin	-0.117±0.338^{b}	-0.672±0.547^{b}	-0.449±0.657^{b}	-0.580±0.442^{b}
Triplet	-0.544±0.527^{b}	-0.507±0.950^{b}	-0.851±1.025^{b}	-0.442±0.884^{ab}
Sex				
Male	0.344±0.389	0.332±0.660	0.404±0.756	0.536±0.573
Female	-0.344±0.370	-0.332±0.619	-0.404±0.720	-0.536±0.527
Month of Birth				
February	1.697±0.527^{a}	3.317±0.949^{a}	3.803±1.025^{a}	3.398±0.883^{a}
March	1.155±0.384^{a}	2.173±0.649^{a}	2.457±0.747^{ab}	2.129±0.561^{ab}
April	-0.034±0.660^{bc}	-0.898±1.218^{bc}	1.025±1.284^{cde}	-0.341±1.160^{cd}
May	-1.256±0.552^{cd}	-2.917±1.000^{c}	-1.958±1.073^{e}	-2.294±0.936^{d}
September	-1.754±0.379^{d}	-2.819±0.638^{c}	-3.269±0.737^{e}	-2.862±0.548^{d}
October	-0.971±0.672^{cd}	-0.747±1.244^{bc}	-1.447±1.308^{de}	-1.288±1.186^{cd}
November	0.749±0.398^{ab}	1.584±0.680^{ab}	1.169±0.775^{bc}	1.039±0.596^{bc}
December	0.414±0.383^{b}	0.307±0.648^{b}	0.271±0.746^{cd}	0.219±0.560^{c}
Type of Birth x Sex				
Single male	-0.047±0.356	0.171±0.589	0.193±0.694	-0.085±0.492
Single female	0.047±0.357	0.171±0.591	-0.193±0.696	0.085±0.495
Twin male	0.117±0.356	0.612±0.587	0.414±0.692	0.228±0.490
Twin female	-0.117±0.349	-0.612±0.574	-0.414±0.681	0.228±0.474
Triplet male	-0.069±0.710	-0.782±1.317	-0.607±1.380	-0.143±1.260
Triplet female	0.069±0.622	0.782±1.141	0.607±1.209	0.143±1.081
Regression				
Dam's weight at kidding	0.028±0.011	0.064±0.022	0.058±0.022	0.064±0.021

Contd.

Table 2.6 : Contd.

AT 4 MONTH

Factors	Body Weight	Body Length	Withers' Height	Chest Girth
u	9.503±0.461	47.644±0.773	49.499±0.699	46.281±0.714
Year of birth				
1982	0.123±0.573	0.359±0.980	-0.225±0.933[a]	1.416±0.918[a]
1983	0.254±0.486	0.407±0.820	0.852±0.754[a]	0.123±0.761[b]
1984	-0.378±0.532	-0.767±0.905	-0.627±0.849[a]	1.539±0.844[c]
Type of birth				
Single	0.583±0.449[a]	1.194±0.752[a]	1.287±0.675[a]	1.181±0.693[a]
Twin	-0.050±0.447[a]	-0.536±0.747[a]	-0.425±0.660[b]	-0.497±0.687[a]
Triplet	-0.533±0.669[a]	-0.657±1.154[a]	-0.862±1.123[b]	-0.684±1.088[a]
Sex				
Male	0.414±0.510	0.656±0.864	0.522±0.804	0.389±0.804
Female	-0.414±0.477	-0.656±0.803	-0.522±0.734	-0.389±0.743
Month of Birth				
February	1.663±0.649[a]	3.127±1.119[a]	3.559±1.084[a]	3.099±1.054[a]
March	1.004±0.501[a]	1.630±0.849[ab]	1.689±0.786[ab]	2.220±0.788[a]
April	-1.048±0.798[bcd]	-2.122±1.387[cd]	-2.032±1.373[cd]	-1.194±1.310[bc]
May	-1.284±0.703[cd]	-4.035±1.217[d]	-3.211±1.191[d]	-3.793±1.149[c]
September	-1.677±0.501[d]	-2.779±0.849[d]	-2.758±0.786[d]	-2.149±0.789[c]
October	0.310±0.806[abc]	1.070±1.402[abc]	1.010±1.388[abc]	1.416±1.328[ab]
November	0.698±0.571[ab]	2.614±0.975[a]	1.099±0.928[abc]	0.849±0.913[ab]
December	0.334±0.502[ab]	0.497±0.850[bc]	0.644±0.787[bc]	0.295±0.790[b]
Type of Birth x Sex				
Single male	-0.032±0.467	0.006±0.784	0.267±0.712	0.097±0.725
Single female	0.032±0.470	-0.006±0.790	-0.267±0.719	-0.097±0.730
Twin male	-0.003±0.470	0.128±0.790	0.169±0.719	0.144±0.730
Twin female	0.003±0.467	-0.128±0.772	-0.169±0.698	-0.144±0.713
Triplet male	0.035±0.913	-0.134±1.595	-0.436±1.591	-0.242±1.515
Triplet female	-0.035±0.748	0.134±1.297	0.436±1.276	0.242±1.227
Regression				
Dam's weight at kidding	0.028±0.015	0.077±0.026	0.069±0.027	0.077±0.025

Contd.

Table 2.6 : Contd.

AT 5 MONTH

Factors	Body Weight	Body Length	Withers' Height	Chest Girth
u	10.753±0.520	49.862±0.787	51.383±0.883	48.653±0.781
Year of Birth				
1982	0.149±0.688	-0.184±1.056	-0.739±1.154	1.298±0.053
1983	0.179±0.565	0.529±0.858	0.880±0.954	0.177±0.854
1984	-0.329±0.630	-0.345±0.963	-0.141±1.060	-1.476±0.959
Type of Birth				
Single	0.832±0.511	1.179±0.772[a]	1.362±0.868	1.276±0.766
Twin	-0.225±0.503	-0.720±0.758[b]	-0.425±0.855	-0.535±0.753
Triplet	-0.607±0.808	-0.459±1.245[b]	-0.936±1.349	-0.740±1.244
Sex				
Male	0.489±0.589	0.722±0.897	0.458±0.994	0.578±0.893
Female	-0.489±0.545	-0.722±0.827	-0.458±0.924	-0.578±0.823
Month of Birth				
February	1.374±0.788	2.200±1.213[a]	2.484±1.316[a]	2.572±1.211[ab]
March	0.538±0.578	0.495±0.879[a]	1.308±0.976[a]	1.134±0.875[ab]
April	-1.292±0.977	-3.363±1.510[bc]	-2.034±1.633[b]	-2.343±1.510[cd]
May	-1.867±1.020	-4.543±1.579[c]	-5.864±1.695[c]	-4.041±1.580[d]
September	-0.884±0.587	-0.442±0.894[ab]	-1.063±0.991[b]	-0.800±0.889[cd]
October	1.674±1.305	3.517±2.026[a]	3.998±2.162[a]	4.414±2.029[a]
November	0.557±0.697	2.481±1.069[a]	0.801±1.169[ab]	0.046±1.066[bc]
December	-0.099±0.573	-0.345±0.871[ab]	0.368±0.968[ab]	-0.981±0.866[cd]
Type of Birth x Sex				
Single male	0.147±0.537	0.394±0.813	0.576±0.910	0.250±0.808
Single female	-0.147±0.551	-0.394±0.837	-0.576±0.933	-0.250±0.832
Twin male	-0.114±0.539	-0.220±0.818	0.061±0.914	0.064±0.813
Twin female	0.114±0.526	0.220±0.796	-0.061±0.892	-0.064±0.791
Triplet male	-0.032±1.130	-0.174±1.751	-0.638±1.875	-0.315±1.753
Triplet female	0.032±0.913	0.174±1.411	0.628±1.521	0.315±1.411
Regression				
Dam's weight at kidding	0.027±0.020	0.042±0.031	0.042±0.033	0.039±0.032

Contd.

Table 2.6 : Contd.

AT 6 MONTH

Factors	Body Weight	Body Length	Withers' Height	Chest Girth
u	12.557±0.537	52.274±0.708	54.475±0.842	50.677±0.864
Year of Birth				
1982	0.870±0.674	0.103±0.960	-0.767±1.082[b]	1.322±1.056
1983	-0.031±0.570	0.519±0.772	0.926±0.901[a]	0.110±0.911
1984	-0.838±0.671	-0.623±0.956	-0.158±1.077[ab]	-1.432±1.053
Type of Birth				
Single	0.776±0.518	1.251±0.653	1.042±0.809	1.177±0.839
Twin	0.068±0.515	-0.254±0.666	-0.307±0.803	-0.095±0.835
Triplet	-0.843±0.848	-0.997±1.263	-0.734±1.381	-1.082±1.305
Sex				
Male	0.724±0.611	0.871±0.848	1.039±0.974	1.029±0.969
Female	-0.724±0.564	-0.871±0.759	-1.039±0.889	-1.029±0.901
Month of Birth				
February	0.737±0.903	0.783±1.355[ab]	0.537±1.475[ab]	1.402±1.384
March	0.373±0.594	-0.537±0.816[ab]	0.410±0.943[ab]	0.569±0.944
April	-0.785±1.155	-3.155±1.776[b]	-2.987±1.903[b]	-2.240±1.752
May	-	-	-	-
September	0.275±0.591	0.051±0.812[ab]	-0.649±0.939[b]	-0.695±0.941
October	0.677±1.040	2.364±1.585[a]	2.817±1.707[a]	2.078±1.583
November	-0.128±0.618	1.982±0.860[a]	0.804±0.984[ab]	0.256±0.977
December	-1.148±0.596	-1.489±0.819[b]	-0.939±0.945[b]	-1.370±0.946
Type of Birth x Sex				
Single male	-0.017±0.546	0.072±0.728	-0.015±0.860	0.042±0.878
Single female	0.017±0.548	-0.072±0.731	0.015±0.863	-0.042±0.880
Twin male	-0.093±0.549	-0.128±0.733	-0.226±0.865	-0.194±0.882
Twin female	0.093±0.546	0.128±0.726	0.226±0.858	0.194±0.877
Triplet male	0.109±1.197	0.055±1.844	0.241±1.972	0.152±1.812
Triplet female	-0.109±0.961	-0.055±1.454	-0.241±1.574	-0.152±1.469
Regression				
Dam's weight at kidding	0.028±0.019	0.039±1.032	0.045±0.033	0.047±0.029

Contd.

Table 2.6 : Contd.

AT 7 MONTH

Factors	Body Weight	Body Length	Withers' Height	Chest Girth
u	13.690±0.739	54.348±1.020	55.979±1.066	53.171±1.006
Year of Birth				
1982	0.936±0.850	0.253±1.175	-0.482±1.226	0.519±1.157
1983	-0.470±0.753	-0.218±1.039	0.542±1.085	-0.083±1.024
1984	-0.465±1.014	-0.035±1.401	-0.059±1.462	-0.436±1.380
Type of Birth				
Single	1.271±0.653	1.319±0.901	1.695±0.941	1.458±0.888
Twin	0.069±0.616	-0.603±0.850	-0.173±0.887	-0.113±0.838
Triplet	-1.340±1.569	-0.716±2.168	-1.522±2.264	-1.345±2.137
Sex				
Male	0.391±1.071	0.999±1.480	0.580±1.545	0.718±1.458
Female	-0.391±0.659	-0.999±0.910	-0.580±0.950	-0.718±0.897
Month of Birth				
February	-0.583±1.178	-1.327±1.627	-0.514±1.699	-0.669±1.604
March	0.093±0.636	-0.981±0.878	0.128±0.917	-0.875±0.865
April	-	-	-	-
May	-	-	-	-
September	0.198±2.733	-0.743±3.778	-3.004±3.945	-0.387±3.725
October	1.554±2.067	2.872±2.857	4.645±2.983	4.528±2.816
November	-0.504±0.734	1.816±1.013	-0.080±1.058	-0.543±0.998
December	-0.758±0.677	-1.636±0.934	-1.176±0.975	-2.052±0.920
Type of Birth x Sex				
Single male	0.269±0.722	-0.062±0.997	0.304±1.041	0.153±0.982
Single female	-0.269±0.712	0.062±0.983	-0.304±1.026	-0.153±0.968
Twin male	0.266±0.747	-0.082±1.032	0.369±1.077	0.098±1.017
Twin female	-0.266±0.648	0.082±0.894	-0.369±0.934	-0.098±0.881
Triplet male	-0.534±2.757	0.195±3.812	-0.673±3.980	-0.251±3.757
Triplet female	0.534±1.161	-0.145±1.605	0.673±1.675	0.251±1.581
Regression				
Dam's weight at kidding	0.009±0.032	-0.016±0.044	-0.005±0.046	-0.018±0.043

Contd.

Table 2.6 : Contd.

AT 8 MONTH

Factors	Body Weight	Body Length	Withers' Height	Chest Girth
u	14.408±1.486	54.444±1.918	56.882±1.825	53.169±1.870
Year of Birth				
1982	2.062±1.199	1.991±1.522	1.449±1.448	3.094±1.484
1983	0.278±1.114	1.253±1.403	1.415±1.335	1.427±1.368
1984	-2.341±3.411	-3.244±4.508	-2.864±4.287	-4.521±4.395
Type of Birth				
Single	0.982±1.442	1.053±1.858	1.029±1.767	1.435±1.811
Twin	-0.037±1.385	-0.623±1.779	-0.297±1.692	-0.246±1.735
Triplet	-0.944±2.298	-0.431±3.018	-0.731±2.870	-1.189±2.942
Sex				
Male	0.365±1.762	0.734±2.294	1.002±2.182	0.358±2.237
Female	-0.365±1.429	-0.734±1.840	-1.002±1.750	-0.358±1.794
Month of Birth				
February	0.307±3.503	-0.366±4.031	0.164±4.404	1.477±4.515
March	-0.047±1.377	-1.376±1.769	-0.120±1.682	-1.096±1.725
April	-	-	-	-
May	-	-	-	-
September	0.667±3.491	-0.560±4.615	-1.631±4.389	-0.237±4.499
October	1.210±2.289	2.397±3.005	3.490±2.858	3.432±2.930
November	-1.096±1.428	1.862±1.839	-0.426±1.749	-0.983±1.793
December	-1.041±1.376	-1.956±1.767	-1.481±1.681	-2.593±1.723
Type of Birth x Sex				
Single male	0.700±1.480	0.611±1.910	0.233±1.816	0.782±1.862
Single female	-0.700±1.514	-0.611±1.955	-0.233±1.860	-0.782±1.907
Twin male	0.306±1.546	-0.084±2.000	0.092±1.902	0.068±1.950
Twin female	-0.306±1.387	0.084±1.782	-0.092±1.695	-0.068±1.738
Triplet male	-1.007±3.511	-0.527±4.642	-0.326±4.415	-0.850±4.525
Triplet female	1.007±2.017	0.527±2.639	0.326±2.510	0.850±2.572
Regression				
Dam's weight at kidding	-0.015±0.051	-0.041±0.067	-0.012±0.064	-0.047±0.065

Contd.

Table 2.6 : Contd.

AT 9 MONTH

Factors	Body Weight	Body Length	Withers' Height	Chest Girth
u	16.469±0.901	57.852±1.680	59.679±1.345	55.956±1.375
Year of Birth				
1982	0.943±0.999	0.783±1.323	0.453±1.469	0.499±1.495
1983	-0.943±0.910	-0.783±1.184	-0.453±1.357	-0.499±1.387
1984	-	-	-	-
Type of Birth				
Single	0.377±0.874	0.779±1.127	0.925±1.312	0.717±1.344
Twin	-0.191±0.892	-0.359±1.156	-0.051±1.335	-0.388±1.365
Triplet	-0.185±1.369	-0.420±1.883	-0.874±1.947	-0.328±1.960
Sex				
Male	0.930±1.013	1.184±1.343	1.388±1.486	1.479±1.511
Female	-0.930±0.937	-1.184±1.226	-1.388±1.391	-1.479±1.419
Month of Birth				
February	-0.147±3.038	-0.545±4.312[ab]	-0.839±4.182	0.372±4.161
March	0.342±1.028	-1.032±1.367[ab]	0.623±1.506	-0.269±1.530
April	-	-	-	-
May	-	-	-	-
September	-0.238±0.831	1.428±1.057[ab]	0.748±1.258	-0.446±1.292
October	0.619±1.506	0.552±2.084[ab]	1.218±2.127	0.725±2.135
November	-0.526±0.848	1.586±1.085[a]	-0.540±1.280	0.589±1.312
December	-0.049±0.824	-1.989±1.047[b]	-1.209±1.251	-0.971±1.285
Type of Birth x Sex				
Single male	0.176±0.921	0.035±1.201	0.037±1.371	-0.220±1.400
Single female	-0.176±0.914	-0.035±1.190	-0.037±1.362	0.220±1.391
Twin male	0.123±0.949	-0.090±1.246	-0.121±1.407	-0.561±1.434
Twin female	-0.123±0.945	0.090±1.239	0.121±1.401	0.576±1.429
Triplet male	-0.299±1.886	0.055±2.643	0.084±2.632	0.735±2.631
Triplet female	0.299±1.552	-0.055±2.152	-0.084±2.187	-0.735±2.194
Regression				
Dam's weight at kidding	-0.006±0.035	-0.076±0.050	0.009±0.048	-0.001±0.048

Contd.

Table 2.6 : Contd.

AT 10 MONTH

Factors	Body Weight	Body Length	Withers' Height	Chest Girth
u	17.791±1.107	58.380±1.417	60.416±1.387	56.829±1.338
Year of Birth				
1982	0.575±1.233	0.416±1.577	0.282±1.539	0.298±1.489
1983	-0.575±1.177	-0.416±1.506	-0.282±1.469	-0.298±1.421
1984	-	-	-	-
Type of Birth				
Single	0.514±1.099	0.977±1.406	1.322±1.372	1.419±1.328
Twin	0.256±1.069	0.053±1.368	0.702±1.335	0.384±1.292
Triplet	-0.770±2.244	-1.030±2.871	-2.025±2.801	-1.804±2.710
Sex				
Male	0.167±1.518	0.133±1.942	0.490±1.894	0.228±1.833
Female	-0.167±1.059	-0.133±1.356	-0.490±1.322	-0.228±1.279
Month of Birth				
February	-0.318±3.718	-0.859±4.757	-2.128±4.641	-1.012±4.491
March	-0.975±1.129	-0.673±1.445	-0.211±1.409	-0.359±1.364
April	-	-	-	-
May	-	-	-	-
September	0.314±3.686	1.227±4.716	-0.071±4.602	1.285±4.452
October	3.547±2.858	1.202±3.658	4.346±3.569	3.063±3.453
November	-1.508±0.939	1.364±1.202	-0.934±1.173	-0.785±1.135
December	-1.060±0.945	-2.262±1.209	-1.003±1.179	-2.192±1.141
Type of Birth x Sex				
Single male	1.005±1.212	0.929±1.551	0.667±1.514	0.628±1.464
Single female	-1.005±1.213	-0.929±1.552	-0.667±1.514	-0.628±1.465
Twin male	0.480±1.323	0.207±1.693	0.243±1.651	0.418±1.598
Twin female	-0.480±1.154	-0.207±1.477	-0.243±1.440	-0.418±1.394
Triplet male	-1.485±3.748	-1.136±4.796	-0.909±4.680	-1.046±1.528
Triplet female	1.985±1.850	1.136±2.367	0.909±2.309	1.046±2.234
Regression				
Dam's weight at kidding	-0.038±0.068	-0.016±0.087	0.021±0.085	0.002±0.083

Contd.

Table 2.6 : Contd.

AT 11 MONTH

Factors	Body Weight	Body Length	Withers' Height	Chest Girth
u	18.914±0.892	60.831±1.035	63.036±1.062	59.274±1.189
Year of Birth				
1982	1.493±1.334	0.036±1.800	-0.007±1.717	0.150±1.706
1983	-1.493±1.393	-0.036±1.880	0.007±1.794	-0.150±1.782
1984	-	-	-	-
Type of Birth				
Single	-0.462±1.173	-0.327±1.583	0.079±1.511	-0.149±1.501
Twin	0.985±1.099	0.280±1.485	0.947±1.417	0.409±1.407
Triplet	-0.524±2.327	0.047±3.142	-1.027±2.998	-0.259±2.978
Sex				
Male	0.642±1.495	0.386±2.019	0.836±1.927	0.512±1.914
Female	-0.642±1.064	-0.386±1.436	-0.836±1.370	-0.512±1.361
Month of Birth				
February	2.477±3.804	2.698±5.135	2.645±4.899	2.838±4.867
March	0.013±1.491	-2.387±2.012	-1.788±1.920	-1.843±1.907
April	-	-	-	-
May	-	-	-	-
September	1.815±3.729	1.739±5.034	1.316±4.803	1.670±4.771
October	1.164±2.932	-0.699±3.959	1.495±3.777	0.560±3.752
November	-2.877±1.013	0.748±1.368	-2.519±1.305	-1.577±1.297
December	-2.592±1.315	-2.099±1.775	-1.149±1.694	-1.648±1.683
Type of Birth x Sex				
Single male	0.594±1.248	1.175±1.685	0.805±1.607	0.701±1.597
Single female	-0.594±1.424	-1.175±1.923	-0.805±1.834	-0.701±1.823
Twin male	0.874±1.487	0.195±2.007	0.496±1.915	0.519±1.902
Twin female	-0.874±1.167	-0.195±1.576	-0.496±1.504	-0.519±1.474
Triplet male	-1.496±3.632	-1.370±4.903	-1.301±4.678	-1.220±4.647
Triplet female	1.469±2.167	1.370±2.926	1.301±2.792	1.220±2.773
Regression				
Dam's weight at kidding	-0.034±0.103	-0.081±0.139	-0.102±0.133	-0.073±0.132

Contd.

Table 2.7 : Heritability Estimates for Body Weights and Body Measurements at Different Ages in Jamnapari Goats

Age	No. of Observations	K-Value	Body Weight $h^2 \pm$ s.e.	Body Length $h^2 \pm$ s.e.	Withers' Height $h^2 \pm$ s.e.	Chest Girth $h^2 \pm$ s.e.
Birth	524	41.1	-	-	-	0.018±0.048
1 Month	437	34.0	0.096±0.088	0.074±0.079	0.244±0.141	0.110±0.093
2 Month	418	32.5	0.105±0.093	0.181±0.121	0.251±0.146	0.087±0.086
3 Month	390	30.2	0.257±0.152	0.165±0.119	0.258±0.152	0.089±0.091
4 Month	321	24.6	0.376±0.202	0.331±0.188	0.238±0.157	0.301±0.178
5 Month	272	20.5	0.266±0.178	0.243±0.171	0.290±0.186	0.236±0.168
6 Month	313	24.0	0.235±0.157	0.127±0.119	0.196±0.144	0.292±0.176
7 Month	170	12.2	0.001±0.139	-	-	-
8 Month	120	8.6	0.022±0.213	-	-	-
9 Month	211	16.0	0.176±0.171	0.113±0.149	0.245±0.194	0.270±0.202
10 Month	95	6.5	-	-	-	-
11 Month	69	4.3	-	-	-	-
12 Month	148	10.9	0.237±0.239	0.099±0.194	0.117±0.200	0.245±0.241

Records on progeny of 12 sires were used

Table 2.8 : Phenotypic Correlations Among Body Weights at Different Ages in Jamnapari Goats

Weight at	Weight at			
	3 Month	6 Month	9 Month	12 Month
Birth	0.269 ± 0.048**	0.199 ± 0.055	0.117 ± 0.068	0.206 ± 0.081*
3 Month		0.699 ± 0.042**	0.521 ± 0.059**	0.527 ± 0.070**
6 Month			0.756 ± 0.045**	0.675 ± 0.061**
9 Month				0.813 ± 0.049**

*Significant at $P < 0.05$, **Significant at $P < 0.01$

Table 2.9 : Regression Coefficients of Body Weight on Age (in month) With Their Standard Errors for Different Factors

Factor	Alpha	b ± s.e.
Overall	3.977	1.359 ± 0.029**
1. Sex		
Male	4.127	1.415 ± 0.038**
Female	3.828	1.304 ± 0.034**
2. Type of Birth		
Single	4.850	1.312 ± 0.051**
Twin	3.741	1.412 ± 0.051**
Triplet	3.466	1.336 ± 0.053**
3. Year of Birth		
1982	3.499	1.562 ± 0.046**
1983	4.974	1.041 ± 0.180**
1984	2.937	1.507 ± 0.152**
4. Month of Birth		
February	5.099	1.323 ± 0.089**
March	4.651	1.357 ± 0.065**
April	4.278	1.132 ± 0.186**
May	4.170	1.019 ± 0.182**
September	2.465	1.541 ± 0.085**
October	3.429	1.567 ± 0.094**
November	4.634	1.157 ± 0.075**
December	4.368	1.170 ± 0.076**

*Significant at $P < 0.05$, **Significant at $P < 0.01$

DISCUSSION

Sires were chosen at random and it was found that sires had significant effect on weight at 1, 3, 4 and 6 months, on all body measurements at 4 and 5 months, on length at 2 and 3 months, withers' height at 1, 2, 3, 6 and 9 months and on chest girth at 1, 6 and 9 months of age. Significant effect of sire on body weights have also been reported in various breeds (Mukundan et al., 1983 and Mavrogenis et al., 1984).

It was observed that year of birth had significant effect on body weights at birth, 1, 2, 3, 8, 9 and 12 months, on all body measurements at 1, 2, 3 and 12 months, on withers' height and chest girth at birth, 4 and 6 months of age. Significant effect of year of birth on body weights and body measurements have also been reported at different ages in various breeds (Guha et al., 1968; Mohd-Yusuf et al., 1981; Khan and Sahni, 1983; Mavrogenis, 1983; Mukundan et al., 1983; Nagpal and Chawla, 1984; Nagpal and Chawla, 1985 and Malik et al., 1986). This might be due to differences in climate (which is unavoidable) and management in those years.

The effect of type of birth was found to be significant on body weights and body measurements from birth to 7 months of age. Single born kids were heavier and had larger dimensions than twins and triplets. Significant effect of type of birth on body weights and body measurements at different ages in various breeds have also been reported earlier (Sarma et al., 1981; Khan and Sahni, 1983; Mukundan et al., 1983; Ozekin and Akcapinar, 1983; Singh et al., 1983a; Mavrogenis et al., 1984; Sarma et al., 1984; Balk et al., 1985 and Malik et al., 1986). The differences in early perinatal growth (until weaning) are caused, to a considerable extent by maternal factors, such as the size of litter (reflected in individuals' birth weight), the availability of milk, the number of sucklings and their vitality and aggressiveness. The birth weight is significantly correlated with subsequent body weights (Ali, 1980 and Malik et al., 1986). Therefore, kids with higher birth weight tended to be heavier at later ages also. The body weight and body measurements are significantly correlated particularly in early life (Mukherjee et al., 1981), therefore, type of birth had significant effect on body measurements too.

Sex of kid had significant effect on body weights from birth to 6 month (except at 2 months age) and at 12 months age. It also had significant effect on all 3 body measurements at birth, 1, 6, 9 and 12 months, on length at 4 and 5 and on chest girth at 3 months of age. Males were heavier and had larger body measurements. Significant effect of sex on body weights and body measurements at different ages in various breeds have also been reported by different workers (Misra and Rawat, 1984; Nagpal and Chawla, 1984; Naik et al., 1985 and Malik et al., 1986). This might be due to the influence of male sex hormone, which has an anabolic effect (Hafez, 1962) on male kids which are capable of growing at a faster rate during pre- and post-natal development. Since body weight and body measurements are highly correlated, sex of kid influenced the configurational traits also. The non-significant effect of sex on weights after 6 months might be due to the fact that kids were able to compensate subsequently because of adequate pasture availability. However, the difference in length persisted because body length has a relative slower growth as compared to other configurational traits (Wilson, 1958).

The effect of month of birth on body weight and all 3 body measurements was significant from birth to 6 months of age. It had significant effect on length at 7, 8 and 9 months and on length and chest girth at 12 months of age too. In various breeds, it has been reported that month/season of birth had significant effect on body weight and body measurements at different ages (Mavrogenis et al., 1984; Nagpal and Chawla, 1984; Baik et al., 1985; Naik et al., 1985 and Malik et al., 1986). This might be due to the differences in the availability of good quality and quantity of feeds to the does before parturition and to their kids after birth. Moreover, dam's under physiological stress due to excessive heat or other environmental conditions consumed less feed and consequently produced lighter kids. The significant effect on weight and chest girth at 12 months might be due to the fact that good quality of fooder was available to the kids born in February-April and attaining the age of 12 months.

It was also found that interaction (type of birth x sex) had no significant effect on body weights and body measurements at all ages. Non-significant effect of this interaction at different ages has been reported in different breeds (Nagpal and Chawla, 1984; Sarma et al., 1984 and Nagpal and Chawla, 1985). Non-significant effect of interaction in present investigation probably indicated that the difference in body weights and body measurements due to type of birth were the same and/or common in both sexes.

The effect of dam's weight at kidding on body weights and body measurements from birth to 3 months of age was found to be significant and was also significant on body measurements at 4 months of age. Significant effect of post-kidding weight of dams on weights and measurements have been reported at different ages in various breeds (Khan and Sahni, 1983 and Malik et al., 1986). This might be due to the fact that healthy dams can nourish their offspring better in pre- and post-natal developments. Body measurements are highly correlated with weight particularly in early life, hence, these are also affected by dam's post-kidding weight. Maternal effects usually persist until weaning (3 months) and the same was observed under present investigation.

Progenies of 12 sires were analysed to estimate the heritabilities. Due to negative sire-variance component heritabilities for weight at birth, 10 and 11 months and measurements at birth (except chest girth), 7, 8, 10 and 11 months could not be estimated. Heritabilities for weights and measurements at different ages in various breeds have also been reported (Ali, 1983; Mukundan et al., 1983; Darokhan and Tomar, 1983; Madeli and Patro, 1984; Mavrogenis et al., 1984 and Malik et al., 1986). For a low heritable trait, to get a non-negative estimate of h^2 from sire component at least 800 observations are needed if the progeny size is large and if number of progeny per sire is restricted to 30-40, more number of observations are needed (Thompson and Moore, 1963 and Gill and Jonson, 1968). Negative sire-variance could be due to sampling error, selection among sires relationship among sires and genotype x environment interaction etc. but in present investigation sampling fluctuation seems to be the reason. For the same reason few estimates had higher standard errors which reduced their precision. Therefore, to arrive at a valid conclusion large scale studies need to be conducted.

Phenotypic correlation of birth weight with weaning weight was found to be significant, which is similar to the reports of Ayoadae and Butterworth (1982), Misra and Rawat (1984) and Malik et al. (1986). This could be due to maternal influence which persisted upto 3 months. Non-significant correlation of birth weight with subsequent weights might be due to carry over effect of birth weight which persisted until weaning. Weaning weight (3 months weight) was positively and significantly correlated with subsequent body weights. This finding is similar to the report of Mavrogenis et al. (1984). Correlation between weights of two consecutive ages were higher than the two of distant ages. This might be due to the reason that environmental influences were more similar for two consecutive ages than for two distant ages. It may be concluded that birth weight may be a criterian to selection for weaning weight, which in turn may be used as a criterian to select animals for live weight in later life.

Regression of body weight (in kg.) on age (in months) were calculated and found to be significant for all factors. Significant regressions of weight on age have been reported by Sarma et al. (1981), Khan and Sahni (1983) and Mukundan et al. (1984). Males grew faster than females. This could be due to the effect of sex hormone which led to faster growth of males during pre- and post-natal development. Moreover, males were heavier at 12 months too indicating that overall gain in weight was more in males than females. Kids born as twins (b=1.412) had higher weight gain per month than triplets (b=1.336) and singles (b=1.312). Adult weight showed no difference in the types of birth indicating that total weight gain was more in twins than in triplets and singles which could result only when twins grew faster than triplets and singles. Kids born in the months of September and October were having higher growth rate (b=1.541 and b=1.567) than those born in February to April (b=1.323, 1.357 and 1.132, respectively) and in November and December (b=1.157 and 1.170, respectively). This could be due to the reason that kids born in September and October received good quality fodder at the time of weaning resulting in faster growth which is significantly and positively correlated with subsequent growth. Kids born in other months did not receive good quality and quantity of green fodder in early stages of life resulting in poorer early growth which led to less body weight at 12 months of age.

SUMMARY

The objectives of the present study were to examine the effects of various genetic and non-genetic factors on body weights and body measurements from birth to 12 months of age and to estimate various genetic and phenotypic parameters at different ages.

The study was conducted on 524 Jamnapari kids sired by 12 bucks maintained at Central Institute for Research on Goats, Makhdoom, Mathura (UP) during 1982 to 1984. Least-squares technique was used to examine the effects of year, month and type of birth, sex of kid, interaction (type x sex), sire and dam's weight at kidding on weights and measurements at monthly interval from birth to 12 months. Genetic and phenotypic parameters were estimated by Parental Half-sib Correlation and standard statistical methods, respectively.

Sire had significant influence on weights at 1, 3, 4 and 6 months, on body length at 2, 3, 4 and 5 months, on withers' height at 1, 2, 3, 4, 5, 6 and 9 months and on chest girth at 1, 4, 5, 6 and 9 months of age.

Year of birth had significant effect on body weights at 1, 2, 3, 8, 9 and 12 months of age, on length at 1, 2 and 3 months, on withers' height and chest girth at birth, 1, 2, 3, 4, 6 and 12 months of age. It was seen that kids born in the year 1983 were heaviest upto 3 months of age and kids born in 1982 were heavier from 4 to 12 months of age and had larger body measurements at most of the ages.

Type of birth had significant effect on body weights upto 6 months of age and on body measurements upto 7 months of age. Singles were significantly heavier and had larger body measurements than twins and triplets.

Sex of kid had significant effect on body weights at birth, [illegible] 3, 4, 5, 6, 9 and 12 months of age, on all 3 body measurements at birth, 1, 6, 9 and 12 months, on length at 4 and 5 months and on chest girth at 3 months of age. Males were heavier and had larger body measurements than females.

The effect of month of birth was found to be significant on body weights from birth to 6 months and at 12 months of age, on all body measurements from birth to 6 months, on only length at 7, 8 and 9 months and on length and chest girth at 12 months of age. Mostly the kids born during February-April were heavier and had larger body measurements than those born in other months.

Interaction (type x sex) was found to be non-significant on weights and measurements at all ages.

Influence of dam's weight at kidding was found to be significant on body weights from birth to 3 months of age and on 3 body measurements from birth to 4 months of age. Kids born out of heavy dams were heavier and had larger measurements than those born of lighter dams.

Heritabilities for 3, 6, 9 and 12 months were estimated (0.257± 0.152, 0.235±0.157, 0.176±0.171 and 0.237±0.239, respectively). Phenotypic correlation coefficient among weights were calculated. Birth weight was found to be significantly correlated with weaning weight (0.27) and non-significantly with subsequent weights. Mostly, correlation coefficients between weights of two consecutive ages were higher than the two of distant ages.

Regression of body weight (in kg.) on age (in months) showed that males (b=1.415) grew faster than females (b=1.305) and so also the twins than singles and triplets. Kids born in months of September and October had faster growth than those born in February-April and November and December. Overall the growth rate was 1.359 kg./ month.

CONCLUSION

The aim of the present investigation was to study body weights and measurements and various genetic and non-genetic factors affecting them, in Jamnapari goats.

The conclusions derived from this study were:-

1. Singles were heavier and had larger body measurements at most of the ages,but differences were reduced in later stages of growth.

2. Similarly, male had higher body weight and larger body measurements than females.

3. Mostly, kids born during February-April were heavier and larger than those born in other months. However, growth rate was more in the kids born during September-October.

4. Maternal effects persisted upto 4 months of age (3 months for body weights). Kids born out of heavier dams were having higher weight and larger body measurements.

5. Since birth weight was positively and significantly correlated with weaning weight which in turn had positive and high correlation with subsequent weights, birth weight can be used as primary cirterion to select heavier individual and weaning weight could be the main basis for selection.

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WEIGHT-MEASUREMENT RELATIONSHIP AND PREDICTION OF BODY WEIGHT ON THE BASIS OF BODY MEASUREMENTS

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The study of relationship between different characters in any class of animals is helpful in indicating the genetic behaviour of different character and serves as an aid in the selective breeding process. Many studies are available about such relationship in large animals (Mullick, 1950 and Macgukin, et al 1950) but very little work seems to have been carried out in small ruminants such as goats and Jamnapari breed in particular.

A study of relationship between body weights and body measurements can be of great use in the selection and breeding of goats for meat purpose and with this aim present study was undertaken.

The investigation was carried out on 524 kids sired by 12 bucks maintained at Central Institute for Research on Goats, Makhdoom, Mathura (UP) during 1982-1984. Phenotypic correlation coefficients and prediction equations at birth, 3, 6, 9 and 12 months (using stepwise multiple regression technique) were developed according to Snedecor and Cochran (1968). Genetic correlations were estimated by Parental Half-sib Correlation method (Hazel et al., 1943).

Correlation Coefficients

Phenotypic correlation coefficients were calculated between body weight and each of the 3 body measurements i.e. body length, height at withers and chest girth, and among body measurements at different ages and are presented in Table 3.1. It was seen that all correlation coefficients between body weight and body measurements and among body measurements were positive and highly significant ($P < 0.01$). Correlation of weight with body length ranged from 0.61 (at birth) to 0.91 (at 5 months), with withers' height from 0.58 (at birth) to 0.87 (at 5 months) and with chest girth from 0.63 (at birth) to 0.90 (at 8 months of age). Correlations were higher in early stages of life and declined subsequently. Correlations of body weight with chest girth were highest in majority of cases followed by length and height, respectively.

Genetic correlation coefficients were also calculated and are presented along with phenotypic correlation coefficients in Table 3.1. Due to negative sire-variance component heritabilities of these traits could not be estimated at birth 7, 8, 10 and 11 months of age and consequently the genetic correlation coefficients could not be calculated. It was seen that most of the correlation coefficients were positive and highly significant ($P<0.01$); some of these estimates were though high but less precise because of their higher standard errors.

Prediction of Body Weight Using Linear Body Measurements

Relationship of body weight with 3 body measurements i.e. length (X_1) height at withers (X_2) and chest girth (X_3) at various ages (birth, 3 months, 6 months, 9 months and 12 months) as calculated by step-wise multiple regression technique are presented in Tables 3.2.1, 3.2.2, 3.2.3, 3.2.4 and 3.2.5. Maximum R^2 value that can be obtained at birth is approximately 50% by taking all 3 measurements into consideration indicating poor prediction of weight from body measurements. At 3 months (weaning) weight can be predicted from body measurements with fairly high accuracy (R^2=0.79). Only chest girth had a R^2 value of 0.72, highest among the measurements and in combination with length and height R^2 values were 0.77 and 0.78, respectively. At 6 months of age X_3 had a R^2 value of 0.76 alone (maximum among measurements) and 0.82 and 0.80 with length and height, respectively. A combination of all three gave R^2 value of 0.83. At 9 months of age a combination of X_1 and X_2, X_1 and X_3, X_2 and X_3 and X_1, X_2 and X_3 had almost equal accuracy of prediction (R^2 values were 0.79, 0.78, 0.76 and 0.80, respectively). At 12 months of age X_3 alone or in combination with X_1 or X_2 or X_1 and X_2 had more or less same accuracy of prediction (R^2 values were 0.78, 0.79, 0.80 and 0.80, respectively).

Table 3.1 : Phenotypic and Genetic Correlations Between Body Weight and Body Measurements and Among Body Measurements at Different Ages in Jamnapari Goats

Age & Character	No. of Observations	Body Weight	Body Length	Withers' Height	Chest Girth
Birth					
Body Weight	524		0.613**	0.580**	0.629**
Body Length				0.629**	0.639**
Withers' Height					0.521**
Chest Girth					
1 Month					
Body Weight	437		0.721**	0.731**	0.719**
Body Length		0.59±0.43		0.823**	0.747**
Withers' Height		0.65±0.31	>1		0.719**
Chest Girth		0.93±0.10	0.79±0.28	0.80±0.21	
2 Month					
Body Weight	418		0.805**	0.805**	0.806**
Body Length		0.81±0.20		0.862**	0.804**
Withers' Height		0.94±0.12	0.96±0.05		0.772**
Chest Girth		>1	0.97±0.12	>1	
3 Month					
Body Weight	390		0.821**	0.847**	0.850**
Body Length		0.98±0.06		0.879**	0.820**
Withers' Height		0.99±0.03	0.94±0.07		0.826**
Chest Girth		>1	0.89±0.16	>1	
4 Month					
Body Weight	321		0.868**	0.873**	0.844**
Body Length		0.97±0.04		0.887**	0.828**
Withers' Height		0.96±0.05	>1		0.834**
Chest Girth		>1	0.97±0.05	0.98±0.05	
5 Month					
Body Weight	273		0.907**	0.874**	0.874**
Body Length		>1		0.901**	0.879**
Withers' Height		0.95±0.07	1.00±0.03		0.866**
Chest Girth		0.99±0.05	0.97±0.06	>1	

Contd.

Table 3.1 : Contd.

Age & Character	No. of Observations	Body Weight	Body Length	Withers' Height	Chest Girth
6 Month					
Body Weight	313		0.877**	0.867**	0.870**
Body Length		> 1		0.893**	0.866**
Withers' Height		> 1	> 1		0.872**
Chest Girth		> 1	> 1	> 1	
7 Month					
Body Weight	170		0.877**	0.849**	0.825**
Body Length				0.855**	0.818**
Withers' Height					0.814**
Chest Girth					
8 Month					
Body Weight	120		0.869**	0.860**	0.902**
Body Length				0.831**	0.849**
Withers' Height					0.877**
Chest Girth					
9 Month					
Body Weight	211		0.874**	0.857**	0.843**
Body Length		0.91±0.17		0.888**	0.866**
Withers' Height		> 1	0.97±0.13		0.874**
Chest Girth		0.93±0.12	0.97±0.15	> 1	
10 Month					
Body Weight	95		0.816**	0.838**	0.833**
Body Length				0.849**	0.880**
Withers' Height					0.890**
Chest Girth					
11 Month					
Body Weight	69		0.815**	0.800**	0.828**
Body Length				0.788**	0.818**
Withers' Height					0.811**
Chest Girth					
12 Month					
Body Weight	148		0.769**	0.759**	0.764**
Body Length		>1		0.865**	0.846**
Withers' Height		0.94±0.31	0.48±0.92		0.833**
Chest Girth		0.87±0.23	0.98±0.23	> 1	

*Significant at $P<0.05$, **Significant at $P<0.01$

The elements above and below diagonal are phenotypic and genetic correlations, respectively.

Table 3.2.1 : Partial Regression Coefficients of Live Weight on 3 Body Measurements at Birth in Jamnapari Goats

Prediction Equation	α	$b_1 \pm$ s.e.	$b_2 \pm$ s.e.	$b_3 \pm$ s.e.	R^2 (%)
1. $Y = \alpha + b_1 X_1$	-18.8	$0.155 \pm 0.008^{**}$			37.92
2. $Y = \alpha + b_2 X_2$	-17.9		$0.141 \pm 0.008^{**}$		33.96
3. $Y = \alpha + b_3 X_3$	-15.6			$0.146 \pm 0.008^{**}$	39.57
4. $Y = \alpha + b_1 X_1 + b_2 X_2$	-29.2	$0.104 \pm 0.011^{**}$	$0.078 \pm 0.010^{**}$		44.02
5. $Y = \alpha + b_1 X_1 + b_3 X_3$	-27.6	$0.091 \pm 0.010^{**}$		$0.092 \pm 0.009^{**}$	47.20
6. $Y = \alpha + b_2 X_2 + b_3 X_3$	-31.3		$0.084 \pm 0.009^{**}$	$0.103 \pm 0.009^{**}$	48.28
7. $Y = \alpha + b_1 X_1 + b_2 X_2 + b_3 X_3$	-34.7	$0.059 \pm 0.011^{**}$	$0.061 \pm 0.009^{**}$	$0.806 \pm 0.009^{**}$	50.79

*Significant at $P < 0.05$, **Significant at $P < 0.01$

X_1 — Body length, X_2 — Height at withers and X_3 — Chest girth. α — Intercept, b_1, b_2 and b_3 — Partial regression coefficients of weight on body length, withers' height and chest girth, respectively.

Table 3.2.2 : Partial Regression Coefficients of Live Weight on 3 Body Measurements at 3 Months of Age in Jamnapari Goats

Prediction Equation	α	$b_1 \pm$ s.e.	$b_2 \pm$ s.e.	$b_3 \pm$ s.e.	R^2 (%)
1. $Y = \alpha + b_1 X_1$	-11.1	0.424±0.015**			66.59
2. $Y = \alpha + b_2 X_2$	-12.2		0.431±0.014**		71.18
3. $Y = \alpha + b_3 X_3$	-12.2			0.458±0.014**	72.13
4. $Y = \alpha + b_1 X_1 + b_2 X_2$	-13.0	0.169±0.029**	0.285±0.028**		73.55
5. $Y = \alpha + b_1 X_1 + b_3 X_3$	-13.7	0.191±0.022**		0.296±0.023**	76.64
6. $Y = \alpha + b_2 X_2 + b_3 X_3$	-14.2		0.229±0.021**	0.259±0.022**	78.60
7. $Y = \alpha + b_1 X_1 + b_2 X_2 + b_3 X_3$	-14.4	0.076±0.027**	0.180±0.027**	0.237±0.024**	79.03

*Significant at $P < 0.05$, **Significant at $P < 0.01$

X_1, X_2, X_3, α , b_1, b_2 and b_3 are same as in Table 3.2.1.

Table 3.2.3 : Partial Regression Coefficients of Live Weight on 3 Body Measurements at 6 Months of Age in Jamnapari Goats

Prediction Equation	α	$b_1 \pm$ s.e.	$b_2 \pm$ s.e.	$b_3 \pm$ s.e.	R^2 (%)
1. $Y = \alpha + b_1 X_1$	-16.6	$0.558 \pm 0.017^{**}$			76.78
2. $Y = \alpha + b_2 X_2$	-15.9		$0.523 \pm 0.017^{**}$		75.12
3. $Y = \alpha + b_3 X_3$	-16.8			$0.580 \pm 0.018^{**}$	75.64
4. $Y = \alpha + b_1 X_1 + b_2 X_2$	-17.9	$0.322 \pm 0.035^{**}$	$0.251 \pm 0.034^{**}$		80.30
5. $Y = \alpha + b_1 X_1 + b_3 X_3$	-16.8	$0.313 \pm 0.031^{**}$		$0.296 \pm 0.032^{**}$	81.69
6. $Y = \alpha + b_2 X_2 + b_3 X_3$	-16.4		$0.273 \pm 0.031^{**}$	$0.317 \pm 0.034^{**}$	80.54
7. $Y = \alpha + b_1 X_1 + b_2 X_2 + b_3 X_3$	-19.1	$0.227 \pm 0.036^{**}$	$0.149 \pm 0.035^{**}$	$0.230 \pm 0.035^{**}$	82.71

*Significant at $P < 0.05$, **Significant at $P < 0.01$

X_1, X_2, X_3, α, b_1, b_2, and b_3 are same as in Table 3.2.1.

Table 3.2.4 : Partial Regression Coefficients of Live Weight on 3 Body Measurements at 9 Months of Age in Jamnapari Goats

Prediction Equation	α	$b_1 \pm$ s.e.	$b_2 \pm$ s.e.	$b_3 \pm$ s.e.	R^2 (%)
1. $Y = \alpha + b_1 X_1$	-19.2	$0.617 \pm 0.023^{**}$			76.03
2. $Y = \alpha + b_2 X_2$	-20.6		$0.622 \pm 0.026^{**}$		73.00
3. $Y = \alpha + b_3 X_3$	-17.4			$0.605 \pm 0.028^{**}$	68.98
4. $Y = \alpha + b_1 X_1 + b_2 X_2$	-21.8	$0.379 \pm 0.049^{**}$	$0.275 \pm 0.050^{**}$		79.06
5. $Y = \alpha + b_1 X_1 + b_3 X_3$	-20.8	$0.430 \pm 0.045^{**}$		$0.222 \pm 0.046^{**}$	78.40
6. $Y = \alpha + b_2 X_2 + b_3 X_3$	-21.7		$0.395 \pm 0.050^{**}$	$0.261 \pm 0.050^{**}$	76.08
7. $Y = \alpha + b_1 X_1 + b_2 X_2 + b_3 X_3$	-22.2	$0.322 \pm 0.052^{**}$	$0.208 \pm 0.055^{**}$	$0.137 \pm 0.050^{**}$	79.78

*Significant at $P < 0.05$, **Significant at $P < 0.01$

X_1, X_2, X_3, α, b_1, b_2 and b_3 are same as in Table 3.2.1.

Table 3.2.5 : Partial Regression Coefficients of Live Weight on 3 Body Measurements at 12 Months of Age in Jamnapari Goats

Prediction Equation	α	b_1±s.e.	b_2±s.e.	b_3±s.e.	R^2(%)
1. $Y = \alpha + b_1 X_1$	- 18.9	0.621±0.059**	-	-	62.21
2. $Y = \alpha + b_2 X_2$	- 26.3	-	0.720±0.055**	-	71.49
3. $Y = \alpha + b_3 X_3$	- 27.4	-	-	0.785±0.050**	78.54
4. $Y = \alpha + b_1 X_1 + b_2 X_2$	- 27.9	0.249±0.079**	0.505±0.086**	-	75.19
5. $Y = \alpha + b_1 X_1 + b_3 X_3$	- 27.5	0.039±0.093	-	0.746±0.105**	78.60
6. $Y = \alpha + b_2 X_2 + b_3 X_3$	- 28.9	-	0.206±0.111	0.591±0.115**	79.61
7. $Y = \alpha + b_1 X_1 + b_2 X_2 + b_3 X_3$	- 28.9	0.038±0.092	0.206±0.112	0.554±0.147**	79.66

*Significant at $P < 0.05$, **Significant at $P < 0.01$

X_1, X_2, X_3, α , b_1, b_2 and b_3 are same as in Table 3.2.1.

DISCUSSION

All phenotypic correlation coefficients were found to be highly significant ($P < 0.01$). Correlations of body weight with chest girth were highest in majority of the cases followed by length and height, respectively. Significant correlations between weights and measurements have been reported at different ages in various breeds (Tandon, 1966; Singh, 1975; Mittal and Pandey, 1978; Prasad et al., 1981; Darokhan and Tomar, 1983; Mukherjee et al., 1983; Bose and Basu, 1984; Manik et al., 1984 and Misra and Rawat, 1984). Closer relationship between body wieght and chest girth could be due to intimate association of body weight with growth of muscles, bones and visceral organs leading to increase in chest girth. Comparatively lower correlation of body weight with height might be because of the fact that height is due to development of limbs, whose increase in weight is not in consonance with gain in general body weight. A high correlation between weight and length might be due to closer association between weight and growth of muscles and bones leading to increase in length. Correlations declined in later ages simply because after reaching a certain level, height and length ceased to increase. Highly significant genetic correlations between weight and measurements could probably be due to the fact that same set of genes controlled the weight as well as measurements. Negative sire-variance component could be due to less number of sires and the progeny per sire. Due to the same reason some of the standard errors estimated were high.

Prediction equations for weight on the basis of body measurements were developed at birth, 3, 6, 9 and 12 months of age. It was seen that chest girth alone or in combination with length and/or height gave fairly high accuracy at different ages (except at birth). Prediction was poor at birth. Several workers have developed prediction equations for weight on the basis of body measurements at different ages in various breeds (Tandon, 1966; Prasad et al., 1981; Bhattacharya et al., 1984; Bose and Basu, 1984 and Manik et al., 1984). Chest girth was found to be the best predictor of live weight as it has highest correlation with weight and constitute major part of the body weight at all stages of life. Similar findings were reported by Tandon (1966), Singh (1975), Prasad et al., (1981), Mukherjee et al., (1983) and Manik et al., (1984). Prediction at birth was less accurate because of the low correlations between weight and measurements.

It may be concluded that chest girth is an important measurement in predicting live weight. Body weight in the absence of a balance or weighing machine can be predicted with fairly high accuracy with the help of a measuring tape graduated in centimeter. Since, the genetic correlations between weight and measurements are high, measurements can predict the response in body weight in a desired direction.

SUMMARY

The objectives of the present study were (i) to determine some biometrical relationship between weight and measurements and (ii) to develop prediction equations at different ages for body weight based on body measurements.

The records on body weight and measurements from birth to 12 months of age on 524 Jamnapari kids sired by 12 bucks, were used in the present study.

Correlations were calculated by standard statistical technique and prediction equations were developed by stepwise multiple regression technique.

It was seen that phenotypic correlation coefficients between body weight and body measurements and among body measurements were positive and highly significant. They were higher in early life. Correlation coefficients between body weight and chest girth (0.63 to 0.90) were highest in majority of cases followed by length and height, respectively. It was also found that genetic correlations among weights and measurements were mostly high and significant.

Prediction of body weight from body measurement at 3, 6, 9 and 12 months had higher accuracy (R^2 values 0.79, 0.83, 0.80 and 0.80, respectively). It had very low accuracy (R^2= 0.50) at birth. It was seen that chest girth alone or in combination with length and/or height gave fairly high accuracy in predicting weight at different ages (except at birth).

CONCLUSION

The present study was conducted to study the relationship between weight and measurements and to develop prediction equations based on body measurements in Jamnapari goats.

Following conclusions were drawn from the results of this study:-

1. Phenotypic correlation coefficients between body weight and body measurements were positive and highly significant. They were higher in early life.

2. Most of the genetic correlations were positive and significant. There was no genetic antagonism.

3. Correlation coefficients between body weight and chest girth were highest in majority of the cases followed by length and height, respectively.

4. Prediction of weight from body measurements was poor at birth.

5. Chest girth alone or in combination with length and/or withers' height had high accuracy of prediction.

6. In the absence of weighing machine or balance, body weight can be predicted with fairly high accuracy with the help of measuring tape graduated in centimeters.

Chapter - 5

geneticanalysisofgrowthfrombirthtotwelvemonthsofageinjamnaparigoats

SUMMARY

geneticanalysisofgrowthfrombirthtotwelvemonthsofageinjamnaparigoats

SUMMARY

The objectives of the present investigation were (i) to examine the effect of various genetic and non-genetic factors affecting body weights and body measurements from birth to 12 months of age, (ii) to determine biometrical relationship between body weight and body measurements and (iii) to develop prediction equations for body weight on the basis of body measurements.

The investigation was carried out on 524 Jamnapari kids sired by 12 bucks maintained at Central Institute for Research on Goats, Makhdoom, Mathura (UP) during 1982-84. Records on body weights and measurement from birth to 12 months at monthly interval and dam's weight at kidding were used.

Least-squares technique was used to study the effect of various factors. Year, month and type of birth, sex and interaction were the fixed effects whereas, sires were chosen at random. Dam's weight at kidding was considered as covariate in the model. Prediction equations were developed by step-wise multiple regression technique. Heritability and genetic correlations were calculated by Parental Half-sib Correlation method and other statistics were calculated by standard technique.

Sires had significant effect on body weight at 1, 3, 4 and 6 months, on body length at 2, 3, 4 and 5 months, on withers' height from 1 to 6 and at 9 months and on chest girth at 1, 4, 5, 6 and 9 months of age.

Year of birth had significant effect on body weights at 1, 2, 3, 8, 9 and 12 months of age, on length at 1, 2 and 3 months, on withers' height and chest girth at 1, 2, 3, 4, 6 and 12 months of age. It was observed that kids born in 1983 were heaviest upto 3 months of age and those born in 1982 thereafter. Kids born in 1982 had larger body measurements at most of the ages.

Type of birth had significant effect on body weights upto 6 months and on all 3 body measurements upto 7 months of age. Singles were heavier and had larger body measurements than twins and triplets.

Sex of kid had significant effect on body weights at all ages except at 2, 7, 8 and 11 months, on all 3 body measurements at birth,

1, 6, 9 and 12 months, on length at 4 and 5 month and on chest girth at 3 months of age. Males were heavier and had larger body dimensions than females.

The effect of month of birth was found to be significant on body weights upto 6 month and at 12 months of age, on all body measurements upto 6 months, on length at 7, 8 and 9 months and on length and chest girth at 12 months of age. Mostly, February born kids were heavier than those born in other months.

Interaction effect was found to be non-significant on weight and measurements at all ages.

Influence of dam's weight at kidding was found to be significant on body weights from birth to 3 months and on body measurements upto 4 months of age. Kids of heavier dams had higher body weight and larger body measurements.

Heritability of birth weight could not be estimated because of the negative sire-variance component. Heritabilities were 0.26±0.15, 0.23±0.16, 0.18±0.17 and 0.24±0.24 for weights at 3, 6, 9 and 12 months, respectively. Birth weight had positive and highly significant correlation with weaning weight. Weaning weight had positive and significant correlation with subsequent weights. Phenotypic and genetic correlations between weight and measurements and among measurements were positive and highly significant; these were higher in early life.

Correlations (between body weight and each of the body measurements) involving chest girth were highest in majority of the cases followed by length and height, respectively.

Regression of weight (in kg.) on age (in months) showed an overall growth rate of 1.359 kg./month. Males grew faster than females and so also the twins over singles and triplets. Kids born in the months of September-October had faster growth than those born in other months.

Prediction of body weight from body measurements had higher accuracy at 3 months (R^2=0.79), 6 months (R^2=0.83), 9 months (R^2= 0.80) and at 12 months (R^2 = 0.80) of age but very poor at birth (R^2= 0.50). Chest girth alone or in combination with length and/or height gave fairly high accuracy of prediction for body weight.

CONCLUSION

The present investigation was carried out with the following aims :-

1. To study body weights and body measurements from birth to 12 months of age and various genetic and non-genetic factors affecting it.
2. To determine biometrical relationship between body weight and body measurements.
3. To develop prediction equations at different ages for body weight based on body measurements.

The conclusions derived from this study were:-

1. Birth weight was significantly affected by year, month and type of birth, sex and dam's weight at kidding but not by interaction (type x sex) and sire.
2. Kids born in the months of February to April were heavier and larger than those born in other months, however, growth rate was maximum in the kids born during September-October.
3. Singles were heavier and had larger body measurements at most ages but difference was narrowed in later stage of growth.
4. Males were generally heavier and had larger body dimensions than females.
5. Heavier dams produced heavier kids and maternal effects persisted upto 4 months of age (for body weight upto 3 months).
6. Kids having higher birth weight tended to be heavier at later ages too and carry over effect of birth weight persisted upto 5 months of age.

7. Birth weight had positive and significant correlation with 3 months (weaning) weight, whereas, weaning weight had mostly positive and high correlation with weights at subsequent ages. Hence, birth weight could be a primary criterion to select heavier animals and weaning weight could be the main basis.
8. Phenotypic correlations between weight and measurements were positive and highly significant. These were higher in early life. Most of the genetic correlations were positive and significant.
9. Correlation coefficients between body weight and chest girth were highest in majority of the cases followed by length and height, respectively.
10. Prediction of weight from body measurements was very poor at birth but had fairly good accuracy at 3, 6, 9 and 12 months of age.
11. Chest girth could be considered as the best predictor of body weight.
12. In the absence of a balance or weighing machine, body weight can be predicted with fairly high accuracy with the help of measuring tape graduated in centimetres.

Chapter - 6

geneticanalysisofgrowthfrombirthtotwelvemonthsofageinjamnaparigoats

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VITA

*The author, **Sanjeev Kumar**, was born on January 13, 1962 in district Bulandshahar (UP). He passed his High School, Intermediate, B.Sc. Examinations, conducted by U.P. Board of Secondary Education, Allahabad (UP) and Meerut University, Meerut from Bishop Mandel Inter College, Bareilly, M.M.H.V. Inter College and M.M.H. College, Ghaziabad in the years 1976, 1978 and 1980, respectively, and got Ist Division in all the examinations. Thereafter, he joined College of Veterinary Science and Animal Husbandry, C.S.A. University of Agriculture and Technology, Kanpur, Mathura Campus, Mathura in September, 1980, wherefrom he did his B.V.Sc. & A.H. Degree in the year 1984. He got IInd merit scholarship in Ist B.V.Sc. & A.H. and Ist merit scholarship thereafter. He was awarded the prestigeous **"Chancellor's Gold Medal"** for topping the list of successful candidates in B.V.Sc. & A.H. Examiantion, 1984. He was awarded a Junior Fellowship by IVRI to complete his M.V.Sc. in Animal Genetics & Breeding.*

Permanent Address : *Dr. Sanjeev Kumar,*
C/O Sri R.C. Gupta,
9, Rama Park,
Kishan Ganj,
DELHI - 110007.