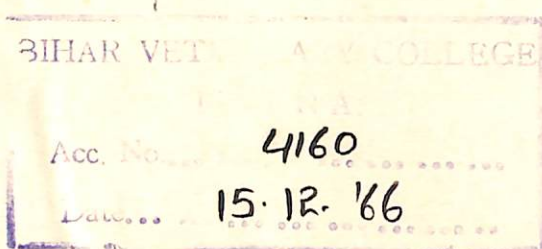


A Study on
Genetic and Environmental Factors
Affecting the Birth Weight & Growth Rate
Of Tharparkar & Hariana Calves.

A Thesis

Submitted to the Faculty of
Veterinary Science & Animal Husbandry,
Magadh University,
In Partial fulfilment of the Requirements
For the Degree of
Master of Science (Animal Husbandry)



By

C. PURNA RAO, B. V. Sc.,
Post Graduate
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November, 1964

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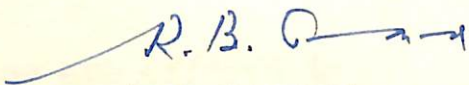
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(November, 1964)

-X-

I certify that this Thesis
has been prepared under my supervision
by C. PURNA RAO, a candidate for the
Degree of M.Sc. (A.H.) with Animal Gene-
tics & Breeding as major subject and
that it incorporates the results of
his independent study.

PATNA,
D/3-11 Novr. '64. 1


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-oOo-

Acknowledgments.

Writing like heredity, requires genes. The genetic endowment of the author is very modest; but he had an enviable environment in the personnel of Dr. R.B. Prasad, M.Sc., Ph. D. (Mich.), U.S.A., Post Graduate Professor and Head of the Department of Animal Genetics, under whose guidance this work has been initiated and accomplished. Amidst his multifarious activities, being the Director of Education & Research in the State of Bihar, his guidance both within and without the purview of this work, has been one of deep understanding and kindness. Whatever sophistication and get-up this work possesses are entirely due his blessings.

The author's obligations are due to Dr. H.R. Mishra, M.Sc., Ph. D. (Minn.), U.S.A., Professor of Animal Husbandry, Bihar Veterinary College, Patna, for the help rendered from time to time.

The raw materials (data) were obtained from the Manager of Government Cattle Farm, Patna, and from Sri R.N. Singh, materials pertaining to Hariana herd at Dumraon. The help rendered is acknowledged gratefully.

Sincere gratitudes are offered to Sri J.N. Prasad, M.Sc. (Statistics), Research Officer (Statistics), Livestock Research Station, Patna, for the designs of this work.

The author wishes to acknowledge the work of Sri K. Krishna Rao, Stenographer, whose efficiency and art have made this work possible.

... AUTHOR.

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INTRODUCTION.

Chapter (1)

INTRODUCTION.

The dependence of man on domestic animals as a source of power and food is time immemorial. With the advancement of time, the discovery of several means of transport and agricultural machinery has minimised this dependence for power to a considerable extent.

Man needs a certain amount of energy and body-building materials which he procures judiciously from plants and animals. However with the passing of time, the increase in cattle and human population has resulted in an ever increasing competition for the available foods of plant origin. One redeeming feature of this struggle is that the competition is less for foods high in cellulose, which the ruminant makes use of by a remarkable symbiosis of rumen microflora.

India with its abounding cattle population rich in number, and poor in performance presents an entirely different picture. A large section of people are vegetarians. The total cultivable land is 371 million acres (Hand Book of Animal Husbandry, 1963), most of which is in small holdings of less than five acres. The collective farming has not proved to be a success and the peasantry can illafford for machanised farming. The farmer, therefore, has to depend on bullocks for agricultural operations for an unseeable future. The poor return from the land, due to the nature of small holdings and secondly due to lack of scientific cultivation, on recommended lines has resulted in the stock being not given the due care. The neglected animals move about, increasing in number due to indiscriminate breeding. These animals damage standing crops and may become a source of spread of infectious diseases, thus becoming a drain on the agricultural economy of the country. Added to this, people are avarice to slaughter, and in certain states it is banned by Legislation. Moreover the Indian cattle are relatively more resistant to diseases. These factors have contributed to the high livestock population of the

country which runs in astronomical figures of over 215 millions of cattle and buffaloes which is one-third of the total cattle population of the world.

The diet of average Indian is of much less calorific value, compared to other countries. The availability of milk per capita is 5 ozs. per head per day, whereas the physiological requirement of man has been worked out to be 10 ozs. per head per day. These circumstances call for a bold approach in changing the food habits of our countrymen. The clarion call would be, "Produce (better stock) or perish".

The question of providing bullock power for agricultural operations and the need to meet the increasing demands of milk and milk products of a fast developing nation and an equally fast expanding population, assumes vast proportions. At the rate of a pair of bullocks for every ten acres of land, India needs 32 millions of bullocks. The total cultivable land being 326 millions acres as reported by Brar and Sharma, 1963.

The cow has a dual role of producing milk and providing calves for subsequent use as breeding or work animals. The buffalo male stock

is, however, unable to withstand the strain of work as compared to bullocks, as given by Brar and Sharma, (1963). The cow has thus to bear much of the brunt than the buffaloes.

The report of Agricultural Commission in 1937 and subsequent National Income Surveys have revealed that approximately 40% of agricultural income comes from livestock. The contribution of our livestock is as follows:-

Contribution of livestock to total income
from Animal Husbandry 1950-59, at current
prices.

Serial No.	Products.	Percentage to total income from Animal Husbandry.
1.	Milk and milk products. Cattle and buffaloes.	64.5
2.	Cattle dung:	
	(a) Manure ...	9.7
	(b) Fuel and other purposes.	9.7
3.	Meat and its products:	
	(a) Cow and buffaloes.	0.9
	(b) Others (meat and meat products).	7.0
4.	Cattle and buffaloes hides.	1.3
5.	Goat and sheep skin.	1.2
6.	Wool and hair. ...	1.1
7.	Eggs and poultry. ...	2.4
8.	Bones. ...	0.1
9.	Increment in stock ...	2.1

It has been shown that if the existing cows are fed on scientific lines, then their milk yield would go up by 40%. Therefore, it is better to assess first the size of the stock that the existing land resources can afford and to keep apart the same and cull the remaining extra stock.

In order to improve livestock, selection for desired traits should be practiced from the initial stages. The earliest and the least time consuming trait which can be recorded with reasonable degree of accuracy is the Birth Weight. The cost of raising livestock up to their productive age is much higher than their market value, as a result the young stock are not given the proper care due to them. They become uneconomical producers and do not reach their optimum size and standard of performance. However, if the cost of raising the young stock is directed towards the promising few a considerable part of the battle would be won in this war for "Freedom from hunger". Since the birth weight reflects several features of the animals future, the study of factors influencing the same becomes useful.

There is evidence in literature that birth weight influences the physical and functional development of the animal in later life (Dowson, Phillips and Black, 1947; Yao, Dawson and Cook, 1953) as quoted by Singh and Dutt (1961), Singh and Desai (1959); that heavier calves have higher growth rate Singh and Desai (1959), Batra and Desai (1962), Johansson (1962); and that female calves with higher birth weights reach their age at first calving earlier (Singh and Desai, 1959). Divergent views have been expressed regarding the relation of milk yield to growth rate and birth weight.

The weight of new born calf is thus of great importance in judging its health and subsequent performance as well as the health of the cow. The weight of the animal at any stage of life is a phenotypic expression of its genotype. These observations justify the study of factors influencing the birth weight.

Growth has been the subject of study of several workers since decades. The great philosophers devoted considerable attention in the third and fourth centuries B.C. Aristotle recorded data on

growth of animals and Theophrastus did similar work on plants. The real beginning of modern systematic measuring and recording of growth phenomenon is credited to Quetelet in 1834, when he reported on systematic measuring of children. In 1891, Minot contributed the first extensive and fundamental studies on growth of guineapigs, which laid the foundation for future workers. Waters extended the fundamental studies to growth of cattle beginning (1906).

Anyone entrusted with study of growth cannot resist the temptation to quote Rubner, who expressed:

"Throughout the animal kingdom from the simplest micro-organisms to the most complexly organised beings, that in exhaustible power of growth which ever since the genesis of the first protoplasm in the infinite past has created the structure of fossils, remains of former ages, as well as our existence - this capacity to grow has remained as the most remarkable phenomenon of nature, the supreme riddle of all life".

Rate of growth is one of the most important economic factors affecting the age of maturity and in consequence the life-time performance of a dairy animal and in beef cattle the period to reach the market weight. A desired rate of growth is a good indication of the state of health of the herd and of the individuals that constitute the herd. Of several factors affecting the birth weight and rate of growth of heifers nutritional aspects have been studied most extensively. Birth weight has been found to influence growth rate (Martin 1956, quoted by Johansson, 1962), which in turn is influenced by prenatal growth, (Wright, 1921), quoted by De Fries, (1959). Factors other than nutritional also play a significant role.

The outcome of selection processes for rate of growth and birth weight or as a matter of fact any other heritable trait can be understood better by knowing the relative importance of heridity and environment in different periods of animal life. However, certain environmental factors can be identified and eliminated atleast in part, thereby increasing the genetic component of study.

The objective of present study is to place on record the significance or otherwise of the factors affecting the birth weight of calves and their subsequent growth up to one year of age. The study here pertains to Tharparkar and Hariana breed of cattle and encompasses the following studies:-

(A) STUDY OF FACTORS AFFECTING BIRTH WEIGHT:

1. Effect of sex.
2. Effect of calving sequence.
3. Effect of age of dam.
4. Effect of season.
5. Effect of sire.
6. Effect of year.
7. Effect of Gestation length.
8. Effect of preceeding dry period.

(B) HERITABILITY ESTIMATE.

(C) STUDY OF FACTORS AFFECTING THE RATE OF GROWTH:

1. Effect of sex.
2. Effect of season of birth.
3. Effect of sequence of calving.
4. Effect of birth weight.

(D) HERITABILITY ESTIMATE.

(E) GROWTH CURVE.

Chapter (2)

REVIEW OF LITERATURE.

The weight gifted to calf at its birth is contributory. Several factors affect the weight of a young one at birth which eventually influence the growth and well being of the animal. Various workers have reported the significance of contribution of different factors affecting the birth weight.

Before studying the factors which influence the birth weight, it is worthwhile to know precisely as to what happens in the prenatal life. The prenatal life comprises, as quoted by Hammond (1955) of ovum, embryonic and foetal stages. The first phase from fertilisation to implantation lasts for 11 days in cattle (Winters and Peuffel, 1936; Winters et. al. 1942 as quoted by Hammond, 1955). The second phase during which major organs, tissues and systems can be differentiated lasts from 11th to 45th day. The third phase lasts from

embryonic phase to birth, during which period heterogenic growth of various organs and tissues resulting in great and continuous changes in the conformation of the individual.

There is very little gain in weight during the first half of uterine life. At 55 days, it weighs less than 10 g. and at 135 days 1400 g. the greatest gain being made during the last phase of prenatal life. (Bergmann, 1921; Hammond, 1927; Kislovsky and Larchin, 1931 and Winters et. al. 1942).

EFFECT OF SEX ON BIRTH WEIGHT:-

The influence of sex is an important factor of variation in the weight of cattle at all ages. It is observed generally that males are heavier at birth than females. Table No. 2 shows the birth weight of male and female calves as recorded by different workers.

EFFECT OF SEQUENCE OF CALVING:-

The sequence of calving denotes calving in succession, with a certain interval, the overall average of which varies from breed to breed. In the normal reproductive life of an animal with increase in age a corresponding increase in number of calvings and size of the dam results. The reproductive organs also grow proportionally.

It has been observed by Fitch et. al. (1924), Eckles (1919 & 1920) as quoted by Hammond (1955) that calves of first calvers are lighter than those from mature cows. Eckles (1919, 1920) as quoted by Hammond (1955) found that 3rd to 6th calvers gave the heaviest calves at birth, while old cows gave slightly less than the average.

Dinkauser et. al. (1944) found in Blackpied cattle at Friedland Experimental Station that birth weight increased upto 4th calving.

Braude & Walker (1949) observed in dairy Shorthorn breed that calves from 3rd or subsequent lactations were heavier than those from first or second lactations.

Hewit (1951) found that calves of first calvings were 5 lbs. lighter (6.5 %) lesser than average in Redpollled cattle. The calves of first calvings were 4 lbs. lighter (4.5 %) than the average in Friesian cattle. There was no falling of birth weight until after the 11th calving.

Asker and Rageb (1952) in their study of Egyptian cattle found that sequence of calving was responsible for bringing about significant differences in birth weight of calves.

Table showing birth weights of calves.

BREED.	Male.	Female	All.	Significant or not.	Author and year.
1.	2.	3.	4.	5.	6.
Short-horn (milking group).	-	-	69.2	-	Knapp et. al. (1941)
Shorthorn (beef group)	-	-	79.2	-	-do-
Hereford.	29.72 .88 Kg	28.02 .93 Kg	-	-	Pain (1944)
Flemish.	39.9 Kg	36.9 Kg	-	-	Joradao and Assis (1950)
G i r.	24.6 0.9 Kg	23.8 .6 Kg	-	-	Veiga et. al. (1950)
Indo-Brazilian.	30.0 .8 Kg	28.9 .7 Kg	-	-	-do-
Egyptian cattle.	25.77 Kg	23.93 Kg	-	Significant.	Asker and Ragab (1952)
Tharparkar.	48.7 lbs	47.5 lbs	-	-	* Choudry and Sinha (1951)
Holstein.	96.7 lbs	90.3 lbs	-	Significant.	Davis et. al. (1955)
Simental.	46.3 Kg	42.6 Kg	-	-	Petrovic (1956)
G i r.	52.9 lbs	49.6 lbs.	51.4 lbs.	-	Pattabhiraman (1957)
Red Sindhi.	46.5 lbs.	44.8 lbs	45.7 lbs	-	-do-
Kangayam.	46.3 lbs	43.5 lbs	44.9 lbs	-	-do-

(contd.)

1.	2.	3.	4.	5.	6.
Hariana.	51.8 lbs	49.8 lbs	50.8 lbs	signifi- cant.	* Kohli and Suri (1957)
Hariana.	54.39 lbs	49.74 lbs	52.19 lbs	--	* Singh and Desai (1959)
Sahiwal.	52.80 lbs	47.95 lbs	50.2 lbs	signifi- cant.	Singh and Dutt (1961)
Kangayam.	44.6 lbs	41.4 lbs	-	-	* Littlewood (1937)
Ongole.	62.0 lbs	57.7 lbs	-	-	-do-
Sindhi.	44.9 lbs	41.7 lbs	-	-	-do-
Sindhi.	47.2 lbs	43.7 lbs	-	-	* Anantakrishnan & Lazrus (1953)
Holstein- Friesian.	94 lbs	90 lbs	-	-	Gillmore (1952)
Brown- swiss.	85 lbs	80 lbs	-	-	-do-
Shorthorn.	74 lbs	73 lbs	-	-	-do-
Ayrshire.	81 lbs	72 lbs	-	-	-do-
Guernsey.	71 lbs	65 lbs	-	-	-do-
Jersey.	60 lbs	53 lbs	-	-	-do-

(*) Quoted by Singh & Dutt (1961)

Ljubeckii (1953) observed that weights were greatest for calves produced at 3rd to 7th calvings when sired by older bulls and only slightly less in those produced at 3rd to 7th calvings when sired by younger bulls. Calves produced at 8th to 9th calvings had greater live and birth weights than those produced at 1st - 2nd calvings irrespective of age of the sire.

Anantkrishnan and Lazrus (1953) studying the birth weights of calves noted that sequence of calving had significant affect on birth weight of calves of Red Sindhi, Gir and Half Ayrshire X Sindhi breed.

Suchanek (1962) while studying Czechoslovakian Red spotted cattle observed that calves of first calvings were 7% lighter and those of second calvings 2.7 % lighter than calves of subsequent calvings, between which there was no appreciable difference.

Stegenga (1962) reported that calves of heifers aged about 2 years were 2.8 Kg lighter at birth than calves born to older cows. The breed under study was Dutch Friesian cattle.

Ridler et. al. (1963) found in Friesians and Shorthorns that calves of first pregnancy were smaller than those born to later ones.

Dickenson (1960) as quoted by Ridler et. al. (1963) suggested that calves of first calvings experienced restricted growth in utero leading to smaller birth weights.

Kohli & Suri (1957) stated that in Haryana cattle the sequence of calving did not affect the birth weight significantly.

Lall and Rizvi (1959) reported that sequence of calving had no significant affect on birth weight in Murrah buffalo calves.

EFFECT OF AGE OF DAM:-

The age of the dam influences the birth weight. The affect of age of dam is analogous to that of sequence of calving and the size of the dam as well. In a normal reproductive life of an animal, with increasing age of dam, the number of calvings increases and so also the size of the dam with each calving. The size of the dam influences the size and hence the weight of the calf at birth. Females of larger breeds give birth to larger calves. Also larger individuals in a breed produce larger calves.

Eckles (1919) and Knapp et. al. (1942) as quoted by Hammond (1955) found that larger dams gave birth to larger off-springs than smaller ones.

Some of these authors found the size of the dam to be the most important single factor in determining the birth weight.

Kudalicka (1949) found in Bohemian and Moravian pied cattle that cows over six years influenced the effect of length of dry period on the birth weight of calves. This relationship was smaller in younger cows (upto five years of age).

Anantakrishnan and Lazrus (1953) observed in Red Sindhi, Gir and $\frac{1}{2}$ Ayrshire X Sindhi breed that the age of dam at first calving had no influence on the birth weight.

In Herford cattle, Lasely, Day and Comfort (1961) found that age of dam had a significant effect on birth weight of calf ($P < .01$).

Singh and Dutt (1961) studying the birth weights of Sahiwal cattle found that the birth weight of Sahiwal calves tended to increase at the rate of 0.152 lbs. in male and 0.214 lbs. in female per month increase in the age of dam. When birth weights were adjusted to the basis of 7 year old dams male calves averaged 2.5 lbs. heavier than females.

Investigations on about 4,000 Dutch Friesian calves by Stegenga (1961) revealed that calves born to heifers aged approximately 2 years were 4.8 Kg. lighter at birth than calves born to older cows.

EFFECT OF SEASON OF CALVING:-

The effect of season of calving if any on the birth weight of calf is indirect. The first effect to be effected being the pregnant animal. The rate of growth of calf is maximum during the last third of pregnancy. Hence those cows in which the last third of pregnancy falls in the season. When the environmental conditions are optimum and when there is no prevalence of any disease there is every likelihood of better birth weight within the limits for the breed. The difference, if any, may, however, be significant or insignificant.

Knapp and Lambert (1944) in Shorthorn breeds, Braude & Walker (1949) in Dairy Shorthorn calves Askar and Ragab, (1952), in Egyptian cattle and Petrovic, (1956) in Simmental cattle observed that season of calving had no effect on birth weight of calf.

EFFECT OF SIRE:-

The sire and dam in general are equally important in inheritance. The sire, however, has an advantage in being able to have more offsprings in a single season. Therefore, the sire is more important in determining the inheritance of next generation, although not important in determining the inheritance of any one animal. (Lush, 1963).

Paim (1947) observed in Hereford herd that the bull did not influence the weight of calf at birth.

Ragab and Acker (1951) found in Egyptian cattle that the sire of the calf influenced the gestation length significantly. Since the gestation length is positively correlated with birth weight it can be deduced that the sire effects the birth weight of the calf.

Ananta Krishnan and Lazrus (1953) studying the birth weight of calves of Red Sindhi and Gir breed observed that individual sires affected the birth weight of calves.

Contrary to this, it was observed by Kohli and Suri (1957) that the sire had no effect on birth weight of calves in Mariana.

EFFECT OF YEAR:-

The effect of year in general represents the combined affect of management feeding practices, availability of feeds and fodders, which in turn is dependent on rain-fall, temperature etc. and prevalence of diseases.

EFFECT OF GESTATION LENGTH:-

The average length of gestation is a statistical composite picture of many individuals cases no one of which may perhaps have been exactly of the average length (Lush, 1963). The fact that length of gestation is a species characteristic seems to suggest that the length of gestation might be due to direct genetic influence. Variations within species are attributed partly to differences in genetic make up and partly to certain environmental factors such as season, year of service or parturition, age of dam etc. Inter breed differences are hereditary.

There is great species difference in physiological age (state of development at birth) of the young at birth, depending on how great a part of growing period is spent in utero. Among farm animals foal is born in advanced state of development and is physiologically older than the young

of other species at birth. The lamb and calf are born slightly younger physiologically (Hammond, 1955) quoting Lowery (1911); McMeekan et. al. (1943). Within species, breed differences and other genetical factors affect the birth weight.

Dinkauser et. al. (1944) found in Blackpied cattle that birth weight increased with increase in gestation length and vice versa. They observed that gestation length increased upto 6th calving whereas birth weight increased upto 4th calving only.

Braude and Walker (1949) studying the birth weights and body measurements of Dairy Shorthorn calves noted that the length of gestation affected the birth weight to the extent of $.91 \pm .924$ lbs. for each extra day of gestation. This rate of increase was not affected by sex of calf, manner of mating or number of lactations.

Male calves were carried for 1.86 days longer than female calves and this was found to be significant.

Jordao and Assis (1950) observed in Flemish cattle in Brazil that male calves were carried for 1.6 days longer than the average gestation length.

(Table No.3)

TABLE SHOWING AVERAGE GESTATION LENGTH OF CATTLE.

B R E E D.	Male.	Female.	All	Signifi- cant or not.	Author and year.
1.	2.	3.	4.	5.	6.
Shorthorn (Beef group)	-	-	280.8 days	-	Knapp et. al. (1941)
Shorthorn (Milking group)	-	-	281.7 days	-	-do-
Blackpied cattle.	281 days	276.7 days	278.5 days	-	Dinkauser et. al. (1944)
Hereford.	279.58 ± 1.33 days	278.81 ± 1.91 days	--	-	Paim (1944)
Flemish.	277.9 days	277.7 days	277.8 days	-	Jordao & Assis (1947)
Tharparker.	288.50 246 days	285.80 $\pm .48$ days	287.15 $\pm .34$ days	-	Choudry & Sinha (1951)
Egyptian cattle.	289.8 days.	289.2 days	289.5 days	Non- signi- ficant.	Ragab & Asker (1951)
Holstein.	278.9 days	278.4 days	--	-	Davis et. al. (1955)
Bariana.	291.78 $\pm .87$ days	289 $\pm .94$ days	290.73 ± 0.91 days	Signi- ficant.	Kohli & Suri (1957)
Tharparker.	289.49 ± 0.46 days	287.24 ± 0.48 days	288.36 ± 0.35 days	Non- signi- ficant.	Singh et. al. (1958)
Aberdeen- Angus.	--	--	278.6 days	--	Boote et. al. (1960)
Shorthorn.	--	--	275.9 days	--	-do-

... Contd.

1.	2.	3.	4.	5.	6.
Red Sindhi.	286.5 ± 0.5 days	284.5 ± 0.5 days	285.5 ± 0.36 days	--	Singh & Ray (1962)
Sahiwal.	--	--	285.92 ± 5.8 days	--	Singh & Dutt (1961)
Friesian.	--	--	282.28 ± 10.7 days	--	Dessouky and Rakha (1961)
Holstein.			278.9 days	--	U.S.D.A. (1951) quoted by Damasouty (1962)
Jersey.			279.3 days		-do-
Ayrshire.			278.7 days		-do-
Gurensey.			284.0 days		-do-
Brown Swiss.			290.0 days		-do-
Afrikaner.			291.1 days.		Van Grann and Joubert (1961)

Choudry and Sinha (1951) studied the gestation period of Tharparkar in which they observed that there was slight variation in gestation length in different seasons of calving. They also noted that there was no tendency for higher birth weight to be associated with longer gestation period.

Ragab and Asker (1951) observed that male calves were carried for a significantly longer period than female calves in Shorthorns, Shorthorn grades and buffaloes except in Egyptian cattle. Positive correlation was observed for all the three breeds studied. It was + 0.318, + 0.218 and + 0.354 for Egyptian cattle, buffaloes and shorthorn grades respectively (Significant at 1% level). There was no significant difference in the time spent in utero by two sexes in Egyptian cattle. The positive correlation between gestation length and birth weight may be due to the fact that heavier calves of either sex need a longer time to complete their prenatal growth.

Brakel, Rife and Salisbury (1952) recorded 0.77 days longer gestation period for male calves in Ayrshire, Brown Swiss and Jersey breeds.

A positive statistically significant correlation was observed in Ayrshire ($+0.26$), Brown Swiss ($+0.54$), and Jersey ($+0.27$) breeds but not for Gurensy and Holstein-Friesian cows.

Ananta Krishnan and Lazrus (1953) studying Red Sindhi and Gir breed observed a positive significant correlation between birth weight and gestation length for male calves ($+0.245$) but not for female calves ($+0.083$) of Red Sindhi and ± 0.379 for male calves and 0.052 for female calves of Gir breed.

Tantaway and Ahmed (1954) working with Egyptian cattle observed a correlation coefficient of 0.338 between gestation length and birth weight of calf.

Rollinson (1955) in his review on "Hereditary factors affecting reproductive efficiency in cattle" has quoted the findings of several authors.

Jaffar et. al. (1950) found a positive correlation of 0.61 ± 0.09 on unadjusted data and 0.52 ± 0.10 on sex adjusted data. They felt that these effects might be due to common causes.

Brody (1945) as quoted by Hammond (1955) maintains that calves with birth weight less than average for the breed are anatomically and physiologically younger than normal at birth and their heat regulating mechanism is not developed fully. Such animals have consequently less power of survival after birth.

Singh et. al. (1958) in their study on heritability estimate of gestation length in Tharparkar observed that the existing small variations in gestation length was very little genetic and, therefore, they concluded that it is not possible in Tharparkar herd to modify gestation length. Indirectly it indicates that the birth weight cannot be increased by modifying the gestation length.

Defries (1959) studying the gestation length of five major dairy breeds observed that males were carried one day less are approximately 1 lb. lighter at birth than the average for that breed. It was predicted that the mean length of gestation period would be decreased by almost 10 days in three generations if 5% of males and 50% of female calves resulting from shortest gestations were saved as breeding stock. However, the decrease in gestation length may have some

deleterious effects on the well being of the off-spring viz. the incomplete development of heat regulating mechanism referred to previously. The study of this aspect needs experimentation.

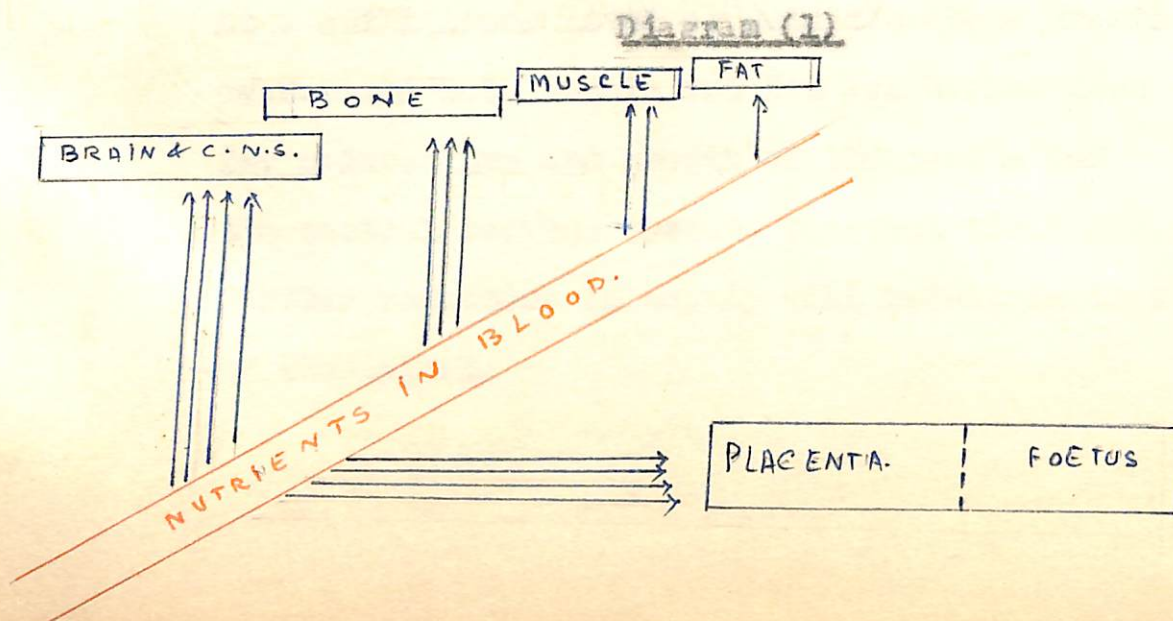
Wright (1921) as quoted by the afore-said authors has stated that birth weight is determined by prenatal growth and the time at which the prenatal growth is terminated by birth. The correlation between gestation length and birth weight indicates a mathematical relationship and not necessarily a casual relationship. Using path coefficients Wright (1921) has demonstrated that birth weight is influenced to a greater extent by prenatal growth rate than by gestation length.

Singh and Dutt (1961) observed that there was a slight relationship between gestation length and birth weight in Sahiwal cattle.

Singh and Ray (1961) noted that there was no correlation between gestation length and birth weight of calf in Red Sindhi cattle.

EFFECT OF DRY PERIOD:-

The period elapsing between two consecutive lactations, when there is no milk, constitutes the dry period. It is only during the dry period and the last week of lactation that a high producing cow regains the calcium and phosphorus drawn from her body resources earlier in the lactation. The rest period enables the cows to rebuild in her body the store of nutrients which she has drawn upon during the height of lactation. This regaining of nutrients and also the "steaming up" practiced at this stage enables the animals to divert more of nutrients towards the growth and development of the foetus. The diagram given below illustrates the interplay between nutrition and the development of different organs, parts and tissues of the body as



explained by Hammond (1956) in "Theory of partition of nutrients according to metabolic rate". In the diagram the number of arrows denotes the metabolic rate of the tissues and the placenta. When the nutritive supply is plentiful, all tissues of growing animal or pregnant female receive sufficient nutrition. When the supply of nutrients is limited, one arrow may be deducted from each tissue and growth of fat is then completely stopped, whereas growth of other earlier maturing tissues continues but at a slower rate. By further reducing the nutritive supply, the direction of the arrow for fat is reversed and another arrow deducted from each of the other tissues and placenta. This illustrates that earlier maturing tissues like brain, bone and foetus still continue to grow and fat is lost to supply the animal with energy. At a still lower level of nutrition bone growth ceases and both muscle and fat are broken down for maintenance and growth of the foetus and the central nervous system, the most vital organ. Further reduction in supply will result in death of the animal.

The importance of steaming up and a reasonable dry period is emphasised here. The extent of effect of preceeding dry period on birth weight has been reported by various workers.

Kudlicka (1949) observed that cows over 500 Kg. of Silesian and Kuhlend breed of cattle influenced the effect of dry period on the weight of new born calf. In all the breeds studied by them the others being (Moravianpled cattle and Bohemian) this relationship was greater in cows (over six years) and smaller with younger cows (upto five years).

Ananta Krishnan and Lazrus (1953) found that there was no correlation between preceeding dry period and birth weight of calf in Gir and Red Sindhi breed. The correlation coefficient was 0.62 and -0.004.

Uman Yu (1933) as quoted by these authors found a positive correlation between length of dry period and birth weight in Red German breed.

Krizenecky and Kudlicka (1944) reported that the weight of the new born calf decreased with a reduction of preceeding dry period in Moravian, Bohemian and Silesian breeds.

Combery and Cersovsky (1956) studying the Blackpied low land breed of cattle reported that there was a definite relationship between dry periods of less than 30 days and birth weight ($r = +.5354$). A longer dry period was not related to increase in birth weight.

(B) HERITABILITY ESTIMATE:-

The magnitude of heritability of any trait indicates the potential effectiveness of selection. Estimating the heritability of various traits is of immense value in implementing selection programmes. Heritability of birth weight as recorded by other authors is given in table 4. (See page 32).

Table (4)

TABLE SHOWING HERITABILITY OF BIRTH WEIGHT.

Breed.	Heritability.	Method.	Author and year.
Beef cattle.	0.23	Intra-sire correlation.	Knapp & Nordskog (1946)
-do-	0.42	Sire-progeny Regression.	-do-
Beef breed.	0.45 (North Platte)	Paternal half-sib.	Gregory, Blunn and Baker (1950)
-do-	1 (Valentine)	-do-	-do-
Egyptian cattle.	0.417	-do-	Asker & Ragab (1952)
Hereford.	0.35	---	Koch and Clark (1955)
-do-	0.44	Regression of offspring on dam.	-do-
-do-	0.35	Regression of progeny average on sire.	-do-
Mariana.	0.135	---	Singh and Desai (1959)
Hereford.	0.67	Paternal half-sib.	Lesley, Day and Comfort (1961)
Sahiwal.	0.2345 .152	Paternal half-sib correlation.	Batra and Desai.
Tharparker.	0.002 .84	Intra-sire, daughter-dam regression.	Singh et. al. (1958)
-do-	0.002 .069	Intra-sire correlation.	-do-
-do-	0.320 .083	Half-sib correlation.	-do-
Beef cattle.	0.53	---	* Quesenberry (1951)

(*) Quoted by Winters.

(C) STUDY OF FACTORS AFFECTING THE
RATE OF GROWTH:-

Of the many factors which might be expected to influence the birth weight and growth rate nutritional aspects have been studied extensively. Control of rate of gain rather than absolute rate of gain has been the main interest. Increased rate of gain is a desirable attribute. For growth studies, it is essential to distinguish between the chronological age and physiological age of the animal (Brody, 1945, as quoted by Hammond, 1955). The chronological time is measured by rotations of the earth around its axis and is assumed to flow uniformly while physiological time is measured by the rate of change in the organism and is, therefore, variable. Quoting Brody (1945):

"If the life-span is 90 days in *Drosophila* and 90 years in *Homo*, we may say that the physiologic clock of the fly runs about 365 times as rapidly as that of man".

Increased rate of growth reduces the unproductive period prior to breedable age. However, it has not been conclusively demonstrated that increased growth rate is closely correlated with life time performance. Some doubt has also been expressed whether the high rate of wastage,

in dairy cows and brood sows, resulting from incidence of disease and reproductive failures may not in part be consequence of rapid growth. Hanshon and his co-workers (1953) using identical twin calves found that the average length of life of heifers on a low plane of nutrition was 95 months compared with 75 months for those reared on a high plane of nutrition (Hammond, 1955).

EFFECT OF SEX ON GROWTH RATE:-

Veiga, Chieffi and Abreu (1950) working with Zebu and Indo-brazilian cattle observed that males of Indo-brazilian breed were somewhat heavier at 24 months than Kankrej. The weights for males at 24 months were:

Kankrej 340.6 - 8.0 Kg;

Indo-brazilian 339.6 - 8.4 Kg;

Nellore 312.5 - 5.9 Kg. and

Gir 273.0 - 5.1 Kg.

Gregory, Blunn and Baker (1950) studying the growth rate of beef calves observed that there was no significant difference in the mean gain of two sexes at North Platte and Valentine stations.

Rollins and Guilbert (1954) observed in beef calves that the lactating ability of cow made a major contribution to the growth of calf throughout the 8-month suckling period. Bull calves gain 0.13 lbs. more per day than heifer calves upto 4 months of age which was not significant.

Davis (1956) studied comparative growth of Ayrshire, Guernsey and Jersey males for first 6 months of life. He observed that Holsteins were heavier at birth and the difference was still apparent at 6 months. The overall growth rate of Ayrshires was slower and that of Jerseys faster than that of other breeds.

Increase in the live weight from birth to 2 years at 6, 12, 18 and 24 months were studied in Chiana heifers by Bujatti (1957). The rate of live weight gain and gain as a percentage of live weight decreased with age.

Records of monthly weights of Ayrshire, Guernsey, Holstein and Jersey young cattle from birth to 2 years were studied by Morrison (1957). It was observed that bulls made distinctly more gains than the heifers of the same breed and also were usually taller at a given age.

Thomas, Marlowe and James (1958)

studied preweaning growth rate and type score of beef calves. They observed that sex of the calf influenced growth rate significantly in both the creep-fed and non-creepfed groups, but has little affect on type score. Bull calves grew approximately 5% faster than steer calves and steer calves grew approximately 8% faster than heifer calves.

Brandt (1958) studying heterosis in dairy cattle as measured by certain observations found that Guernsey X Holstein -Friesian female calves maintained their superiority through 180 days of age over Holstein-Friesian X Gurensey cattle.

Koch and Gregory (1960) evaluating the influence of sex on birth weight and preweaning gain in beef cattle observed that the rates of gain upto weaning for bulls were 1.656 lbs. per day and for heifers 1.543 lbs. per day.

Makela (1960) studying the growth of heifer calves of dairy breed observed that weight gain in first two months was not related to birth weight. From 6 to 18 months growth of heifers was fairly constant and at 18 months live weight was about 330 Kg. Bulls grew faster than heifers.

Growth rate in Egyptian cattle and buffaloes from birth to 1½ years old was studied by Ghoneim and Rafat (1960).

They observed that superiority of males over females was maintained throughout but variations in weights were relatively high. Similar observations were recorded by Suchanek (1961) in Czechoslovak Redspotted cattle.

EFFECT OF SEASON OF BIRTH:-

The effect of season of calving on subsequent growth is consequence of availability of pasture etc. to the cow since the growth rate in first few months is dependent to a very great extent on the lactating ability of the cow.

Phillips (1946) observed in dairy Shorthorns that autumn born calves (October - December) made greater gains during the period of 700 days from birth (737.5 lbs.) than those born during rest of the year. The reason attributed to this was probably a higher nutrition and secondly that the autumn born calves were on grass during their first summer.

Chieffi et. al. (1951) studying the growth of Zebu cattle born during dry season (April - September) and rainy season (October - March) observed that calves born in former season were 3.7 Kg. lighter.

Thomas and Marlowe (1958) studying the growth of beef calves found that season of birth had significant influence on growth of non-creeped calves, but was of no practical importance on growth of creep-fed calves.

Holl and Sramek (1959) found in Czechoslovak heifers that growth was most intense in heifers born September - October and July and August. It was slowest in those born in March - April. The differences became progressively greater and were significant in the second 180 days.

The weight of beef calves at birth, 60, 120, 180 and 240 days of age were studied by Broun (1960). Calves born in autumn were lighter than those born in spring in all comparisons except at 240 days in one herd. He observed further that the increase in calf weight was associated with increase in age of dam upto stage at which the milk production reached its peak.

Suchanek (1961) observed in Czechoslovak Redspotted cattle that the weight gain of spring born calves were less than those of autumn born calves.

Ridler (1963) studying the growth rate of heifers of Shorthorn and Friesian breed from 0 - 6 months observed that autumn born calves of both breeds grew significantly faster than spring born calves during the first 90 days of life. During the second 90 days of life, there were only random differences between the groups.

EFFECT OF SEQUENCE OF CALVING:-

Rollins and Guilbert (1954) found in pure breed Hereford that dams in the age range of 7 - 10 years produced calves that grew faster to 4 months of age and were heaviest at weaning. From 4th month to 8 months of age, the calves from 1st ~~calving~~ calf heifers and to a lesser extent from second calf cows grew faster than those from cows in the optimum age range referred above. This is due to a greater persistency of lactation in young cows compared older cows since several investigations have found this to be the case in dairy cattle.

Dickinson in 1960 (as quoted by Riddler et. al. 1963) suggested that calves born to heifers may grow faster than calves born to older cows, because they have experienced some restriction in utero leading to smaller birth weights. This would also be a form of compensatory growth. However, Riddler et. al. (1963) did not find this to be so in their studies of growth rate Shorthorn and Friesian heifer calves.

EFFECT OF BIRTH WEIGHT ON GROWTH RATE:-

Abelin and Ritter (1962) studied the relationship between birth weight and weight at 1 year in heifer calves in a spotted mountain herd in Grub. They found that birth weight was of no use in predicting subsequent growth, but there was a correlation of $r = + 0.5031$ between 3 months and one year body weight.

Makela (1960) studied growth rate of dairy calves in Vikki Farm. He observed that weight gain in first two months was not related to birth weight, but after the two months period the heavier calves grew faster and bull grew faster than heifers.

Ridler et. al. (1963) studying the growth of Shorthorn and Friesian heifer calves from birth to 6 months found that there were significant negative correlations for calves of both breed born in autumn, between birth weight and rate of live weight gain in first month of life. There was positive correlation between birth weight and rate of gain in fourth month of life.

The heritability of growth rate as recorded by other workers is tabulated in Table No. 2.5. (See page 42).

THE GROWTH CURVE:-

There are many methods of studying growth viz. the actual growth curve, percentage increment method and the weight gained per fixed unit of time. (Minot, 1907; Brody, 1945; Hammond, 1962a). For practical application of growth studies, the actual increment per unit of time or the actual growth curve are used.

The growth curves vary from place to place because of different patterns of feeding adopted at different places. Hence it is difficult to have "standard" growth curves for comparison with the growth rate of other herds of same breed.

Table (5)

HERITABILITY OF GAIN IN WEIGHT.

Breed.	Herita- bility.	Method.	Author and year.
Beef breed Hereford.	0.54 weaning weight.	Regression of parent on average off- spring using gain ratio.	Warwick and Cartwright (1955)
Hereford.	0.21	(as a permanent characteristic of cow).	Koch and Clark. (1955)
-do-	0.70	Regression of off- spring on dam.	-do-
-do-	0.17	Regression of pro- geny average on sire.	-do-
-do-	0.03 weaning weight.	--	Lasley, Day and Comfort (1961)
Beef cattle.	0.3 weaning weight.	Sire progeny regression.	Knapp and Nordskog (1946)
-do-	0.28 weaning weight.	--	* Quisenberry (1951)

-X-

(*) Quoted by Winters (1948). Animal Breeding.
New York. London.

Barlett and Jameson (1932) observed in dairy Shorthorn calves (non-pedigree Shorthorn cows x dairy Shorthorn bulls) that from birth to 6 months of age, the average daily gain live weight increase is not constant, but tends to show a progressively greater increase per day.

Campbell and Flux (1952) recorded in New Zealand Jersey and Friesian cattle that mean weights increased upto 5 months, when the rate of increase declines.

In a preliminary study of growth in Mariana herd at I.V.R.I., Izatnagar, (Annual Report I.V.R.I., 1956-57), it was observed that the body weight was doubled in three months and 350% of birth weight in a year's time. The rate of growth was highest from 12th to 16th week.

Ridler et. al. (1963) studying the growth rate of dairy heifers recorded that rate of gain accelerates from birth to 3 - 4 months of age. At this stage, they observed inflections in growth curve of both the breeds studied as indicated by Brody (1945).

M A T E R I A L S & M E T H O D S.

MATERIALS & METHODS.

SOURCE AND COLLECTION OF DATA:-

The data used for this study comprise of records of Tharparkar herd maintained at the Government Cattle Farm, Patna. The farm was established in October, 1926. Tharparkar breed is maintained in this farm since 1946, prior to which Shahabadi breed was also kept. During the period of study the feeding and management has been on recommended lines. The cows were allowed to graze twice a day after morning and afternoon milking. The maintenance ration of the cow comprised of green fodder, dry fodder and concentrate mixture (1 Kg. per cow per day). The production allowance was 1 Kg. of concentrate for every 3 Kg. of milk. Two ounces of salt and one ounce of mineral mixture was also included. Pregnant cows were fed 2.5 Kg. of concentrates per head per day from 7th month onwards, besides the other constituents of the ration.

The feed schedule for Mariana herd at Dumraon is on similar lines except that the calves are not weaned at birth.

The number of observations recorded for studying the effect of year, sex and season of calving were based on 2323 birth weight of calves born over a period of 18 years from 1946-63 in case of Tharparkar herd and 930 birth weights of calves in the case of Mariana herd born during a period of 13 years from 1951 to 1963.

(For factors other than those mentioned above, data were taken from 1937-63 for Tharparkar herd).

There were 1152 male and 1171 female calves of Tharparkar and 479 male and 451 female calves of Mariana. The calves were born all the year round and their weights were taken as soon as possible after birth. The seasons compared were:

Winter defined as November - January.

Spring defined as February - April.

Summer defined as May - July.

Rainy defined as August - October.

The influence of age of dam on birth weight was studied by classifying the cows into four age groups as below:-

1500 days and below.

1500 - 2000 days.

2000 - 2500 days.

2500 days and above.

The number of observations were 1721 for Tharparkar and 479 for Hariana.

The effect of sequence of calving on birth weight was studied on the basis of 1709 calves in case of Tharparkar herd and 938 in case of Hariana herd. In Tharparkar, calves born in 8th calving and above are classified in one group as "8th calving" and in case of Hariana, calves born in 7th calving and above are grouped under "7th calving".

The correlation between gestation length and birth weight was calculated on the basis of 966 pairs of observations for Tharparkar and 289 pairs for Hariana breed.

To determine increase in weight for a day increase in gestation length above the average gestation length, the regression of birth weight on gestation length was calculated. There were 966 pairs for Tharparkar and 289 pairs for Hariana.

The correlation between preceeding dry period and birth weight was calculated on the basis of 504 pairs of observations for Tharparkar and 301 pairs for Hariana. The dry period exceeding over 324 days were excluded as it was felt to be too high.

The heritability of birth weight was calculated on the basis of 1611 observations for Tharparkar and 714 observations in case of Hariana. The number of sires in case of Tharparkar was 29 and in case of Hariana 19. The sires having less than five off-springs were not included in study.

RATE OF GROWTH:-

The data for studying the factors enumerated earlier on the rate of growth were collected from the same source as for the study of birth weight. The calves were weighed as soon as possible after birth and then at monthly intervals; weights were recorded for the present study upto one year of age. Records of 1963 as could be utilised for study in Tharparkar and of 1961-63 of Hariana herd were taken up for study.

The feed schedule for calves of at Government Cattle Farm, Patna, is as follows:-

Colostrum for 7 days. 3 to 4 litres per calf per day given in morning and evening.

Above one week to one month:-

4 litres of milk per day (divided for two times).

One month to two months:-

4 litres of milk plus 0.5 Kg. of concentrates. Roughages ad lib.

3rd month:-

3 litres of milk divided two times plus one Kg. of concentrates ad lib.

4th - 6th month:-

2 litres of milk per day per head. One Kg. of concentrates. Roughages ad lib.

Heifers 6 months and above:-

1.5 Kg. of concentrates per head per day.
Roughages ad lib.

Male calves 6 months and above:-

Same as for heifers.

In Tharparkar herd calves were weaned at birth.

The monthly weighings were considered for studying pattern of growth curve in both breeds. The live weight growth and rate of gain were plotted. The number of observations for Tharparkar and Hariana herd were 409 and 285 respectively. The total number of cows studied was 127 for Hariana and 129 for Tharparkar herd.

For studying the growth rate, the period of one year was divided into four quarters of 3 months each. The weight gained in each quarter

was recorded separately. ✓ The number of observations under each quarter varied because some of the calves died earlier and some were sold. The total number of observations are same for all the factors, except in the study of effect of season of birth on growth rate in case of Tharparkar herd. Here the number of observations in the fourth quarter were very few and none in the fourth quarter of rainy season. Therefore, growth rate was studied in this particular case upto nine months only. The period of a year was classified into three sections defined as:

March - to June ... Summer.

July - October. ... Rainy.

November - February. ... Winter.

To study the effect of birth weight on growth rate, the average of the breed was calculated. Those above average were classed under one group and those below average under a separate group.

For studying the difference in growth rate of calves of first calving and those of subsequent calvings, the calves were classified accordingly under separate classes.

Similarly the male and female calves were classified separately to study the effect of sex on growth rate.

The heritability of gain of weight at the age of one year was calculated on the basis of 62 observations for Tharparkar and 48 observations were for Hariana herd. The paternal half-sib method was used to estimate heritability.

METHODS.

The average standard error and coefficient of variation were calculated for birth weight, gestation length and dry period and of observations of each quarter of the factors affecting the growth rate.

TEST OF SIGNIFICANCE OF MEANS:-

To test the significance of difference between two means based on independent numbers an estimate of the common standard deviation applicable to both samples was calculated by pooling together the sums of squares corresponding to the two samples and dividing by the total number of degrees of freedom and taking the square root.

$$t = \frac{\bar{m}_1 - \bar{m}_2}{s \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}} \quad \text{with } n_1 n_2 - 2 \text{ d.f.}$$

$$s = \sqrt{\frac{(n_1 - 1) s_1^2 + (n_2 - 1) s_2^2}{n_1 + n_2 - 2}}$$

where s_1 and s_2 are standard deviations of two samples and s is the common standard deviation. This value of "t" is entered in the table of "t" with $n' = n_1 n_2 - 2$ degrees of freedom.

COEFFICIENT OF CORRELATION:-

The coefficient of correlation between two variables X and Y was calculated by finding out the mean product moment or the covariance of the two variables and dividing the same by the product of standard deviations of the two variables.

$$r = \frac{\text{Cov. xy.}}{\sqrt{V(x) \cdot V(y)}}$$

The value of "r" is entered into "r" table by Snedecor (1961) with $n-1$ degree of freedom to test for the significance.

COEFFICIENT OF REGRESSION:-

The coefficient of regression of 'y' on 'x' was calculated by finding the ratio of covariance of two variables to the variance of independent variable and is given by the formula.

$$b_{yx} = \frac{\text{Cov. } xy}{\text{Var. } x}$$

where 'x' is independent variable and 'y' the dependent variable.

ANALYSIS OF VARIANCE:-

Analysis of variance table was run to determine the effect of sire, season, year, sequence of calving, age of dam, on birth weight. In this analysis the total variation is partitioned into various components assignable to different courses. The comparisons of the mean squares due to any cause with the error mean square provided a test of significance of difference arising from that particular cause. The comparison was done by finding the ratio of mean square concerned to error mean square. This ratio was variance ratio denoted by "F".

This was compared with tabulated value to know significance of the ratio. In cases where "F" value was significant, further analysis was done to test the significances of the differences in means, taking two means at a time as described by Snedecor (1961) adopted from Tukey (1953). The test is made by computing a difference "D" which is significant at 5% level, than comparing it with difference in two averages.

The "D" value is given by the formula:

$$D^2 = \left[\frac{1}{n_1} + \frac{1}{n_2} \right] s_e^2 \frac{q^2}{2}$$

where n_1 and n_2 are number of observations on which the two means are based, s_e^2 is the error mean square. The value of "q" is determined by entering into the table given by Snedecor (1963) (Table 10.6.1) for degrees of freedom for number of treatments x 'a' in the horizontal column and 'f' degree of freedom of error mean square in vertical column. If the difference of two means exceeds the value of "D" it indicates that the two means are significantly different.

HERITABILITY ESTIMATE:-

The paternal half-sib method has been used in this study for estimating the heritability of birth weight and growth rate.

The general rule for estimating the half-sib correlation is to subtract the environmental component and then multiplying the remainder by four. This will give an additive genic fraction plus a bit of epistatic variance if the population was mating at random. The intraclass correlation between half-sibs has to be multiplied by four to arrive at the heritability because the correlation between their genic values is expected to be only 1/4th. This is the most serious handicap, as it magnifies sampling error which may be in the estimate and also any other errors which may be in estimating and discounting the environmental component. This method allows the estimate to be much too high or much too low.

The major advantage of this method is that the value contains only the additive plus a small fraction of epistatic portion of hereditary variance. The accuracy of this method dependence on the number of degrees of freedom available for the sires.

The heritability estimate may be obtained from the components of variance as outlined by Hazel and Terril (1945). This method is essentially a method of intraclass correlation.

Analysis of variance table for estimating paternal half-sib correlation and heritability.

Table (A)

S.V.	d.f.	Composition of mean square.
Between sires.	$n-1$	σ^2_B $n_0 \sigma^2_A$
Within sires.	$n(k-1)$	σ^2_B

n_0 = average number of off-springs per sire.

The variance within sire groups (σ^2_B) includes all the random environmental variance, $\frac{3}{4}$ of the genic variance, all of the dominance variance and a major part of epistatic variance. The variance due to sires (σ^2_A) contains 1/4th of the genic variance plus a small fraction of the epistatic variance.

Heritability can be estimated from the following ratio:-

$$h^2 = \frac{4 G^2 A}{G^2 A + G^2 B}$$

The average number of off-springs under each sire is arrived at by the following formula (Snedecor, 1963):-

$$n_o = \frac{1}{a-1} \left(\begin{array}{c} n. - \frac{\sum n_i^2}{\sum n.} \end{array} \right)$$

$n.$ is the number of observations in total

$\sum n_i^2$ is the sum of squares of number of observations under each sire.

Analysis of factors affecting growth rate:-

Due to non-orthogonal nature of data the disproportionate numbers in the sub-classes were subjected to the technique of Fitting of Constants as described by Goulden (1961) and where the interaction was significant estimates of the main effects from the unweighted means was calculated and the significance of these was tested by the method of weighted squares of means as developed by Yates (1939).

The method comprises of preliminary analysis of difference between means followed by procedure of fitting of constants which is as follows:-

PRELIMINARY ANALYSIS OF VARIANCE.

S.V.	d.f.	S.S.		M.S.

Between sub groups.				
Within sub groups.				

Total.				
-X-				

Table (B)

METHOD OF FITTING OF CONSTANTS.

Periods.	FACTOR (I)	FACTOR (II)	N_1	s_1	$\frac{n_{11}}{N_1}$	$s_1 \times \frac{n_{11}}{N_1}$
	n_{11}	s_{11}	n_{12}	s_{12}	$(n_{11} + n_{12})$	$(s_{11} + s_{12})$
1	n_{11}	s_{11}	n_{12}	s_{12}	N_1	N_1
2	n_{21}	s_{21}	n_{22}	s_{22}	N_2	N_2
3	n_{31}	s_{31}	n_{32}	s_{32}	N_3	N_3
4	n_{41}	s_{41}	n_{42}	s_{42}	N_4	N_4

N_1 s_{11} N_2 s_{21} N_3 s_{31} N_4 s_{41} $s = \sum s_i$ $C_1 = \sum s_i \times \frac{n_{11}}{N_1}$

$$C_1 = \left(\frac{n_{11}}{N_1} \right) s_{11} + \left(\frac{n_{12}}{N_2} \right) s_{21} + \dots$$

$$C_{12} = \left(\frac{n_{12}}{N_1} \right) s_{12} + \dots$$

$$b_1 = \frac{s_{11} - C_1}{2 C_{12}}$$

$$\text{S.S. for periods (unadjusted)} = \frac{(s_1.)^2}{N_1.} + \frac{(s_2.)^2}{N_2.} \quad \dots - \text{C.F.}$$

$$\text{S.S. for (factor studied) Adjusted} = C_{12} (2 b_1)^2$$

$$\begin{aligned} \text{S.S. for (factor x period)} &= \text{S.S. between sub-group} - \text{S.S. for factor (adjusted)} \\ &- \text{S.S. for period (unadjusted)} \end{aligned}$$

$$\text{M.S. for interaction} = \frac{\text{S.S. for interaction}}{\text{D.F.}}$$

If the ratio of interaction and M.S. be significant, then the method of weighted squares of means is applied as shown in table (C).

Table (C)

WEIGHTED MEAN SQUARES.

n_{11}	\bar{y}_{11}	n_{12}	\bar{y}_{12}	$\sum \left(\frac{1}{n} \right)$	w_i	$d_{11} = \bar{y}_{11} - \bar{y}_{12}$	$\bar{y}_{11} = \frac{\sum w_i \bar{y}_{11}}{\sum w_i}$	$\bar{y}_{12} = \frac{\sum w_i \bar{y}_{12}}{\sum w_i}$	$\bar{y}_{11} - \bar{y}_{12}$
----------	----------------	----------	----------------	-----------------------------------	-------	--	---	---	-------------------------------

$$\frac{1}{n} \quad \frac{1}{n_{11}} \quad \bar{y}_{11} \quad \frac{1}{n_{12}} \quad \bar{y}_{12} \quad \frac{1}{n_{11}} + \frac{1}{n_{12}} \quad \frac{1}{n_{11}} + \frac{1}{n_{12}}$$

$$\frac{1}{n_{112}} \quad \bar{y}_{112} \quad \frac{1}{n_{122}} \quad \bar{y}_{122}$$

$$\frac{1}{n_{113}} \quad \bar{y}_{113} \quad \frac{1}{n_{123}} \quad \bar{y}_{123}$$

$$\frac{1}{n_{114}} \quad \bar{y}_{114} \quad \frac{1}{n_{124}} \quad \bar{y}_{124}$$

$$\sum \left(\frac{1}{n} \right) \quad x \quad A \quad y \quad B \quad \sum w_i \quad \sum w_i \bar{y}_{11} \quad \sum w_i \bar{y}_{12}$$

$$w_j \quad 1/x \quad 1/y \quad w_j y_j = A/4 \times 1/x \quad B/4 \times 1/y$$

$$w_j \quad 1/4 \quad B/4 \quad \sum w_j \bar{y}_{12}^2$$

Let 'A' represent periods and 'B' factors.

$$\left\{ \left(\frac{w_1 \cdot \bar{y}_1}{w \cdot j} \right) \right\}^2 \quad \left\{ \left(\frac{w_1 \cdot \bar{y}_1}{(w_1 \cdot)} \right) \right\}^2$$

$$\text{S.S. for 'A' } = 4 \left\{ (w_1 \cdot \bar{y}_1)^2 - \frac{(w_1 \cdot \bar{y}_1)^2}{(w_1 \cdot)} \right\}$$

$$\text{S.S. for 'B' } = 16 \left\{ (w \cdot j \cdot \bar{y} \cdot j)^2 - \frac{(w \cdot j \cdot \bar{y} \cdot j)^2}{(w \cdot j)} \right\}$$

$$\text{S.S. for interaction AB } = \sum (w_1 \cdot d_1^2) - \frac{(w_1 \cdot d_1)^2}{(w_1 \cdot)}$$

FINAL ANALYSIS OF VARIANCE.

S.V. 1 d.f. 1 M.S. 1 F.

Between factors.
Between periods.

Interaction.
Error

Total ...

-X-

When the 'F' value of preliminary analysis was non-significant by following procedure as described by Snedecor (1963) was followed.

Table (D)

Periods. ↓	Factor I	↓	Factor II	↓	R. total.
I	n_{11} A (sum of observations)		n_{21} E (sum of observations)		$A + E$ n.1
II	n_{12} B (-do-)		n_{22} F (-do-)		$B + F$ n.2
III	n_{13} C (-do-)		n_{23} G (-do-)		$C + G$ n.3
IV	n_{14} D (-do-)		n_{24} H (-do-)		$D + H$ n.4

-X-

$$n_{11} + n_{12} + n_{13} + n_{14} = n_{1.} \quad n_{21} + n_{22} + n_{23} + n_{24} = n_{2.}$$

$$A + B + C + D$$

$$E + F + G + H$$

$$\text{S.S. (factor)} = \frac{(A + B + C + D)^2}{n_{1.}} + \frac{(E + F + G + H)^2}{n_{2.}} - \text{C.F.}$$

$$\text{S.S. for periods} = \frac{(A + E)^2}{n.1} + \frac{(B + F)^2}{n.2} + \frac{(C + G)^2}{n.3} + \frac{(D + H)^2}{n.4} - \text{C.F.}$$

In 'r' x 'c' table with disproportionate number when 'F' value of preliminary analysis is significant, the following procedure is adopted:-

Table (E)

Per-iods.	s_1	s_2	s_3	$N_1.$	$s_1.$	$\frac{n_{11}}{N_1.}$	$\frac{n_{12}}{N_1.}$	$\frac{n_{13}}{N_1.}$
	n_{11}	n_{12}	n_{13}					

$$n_{11} \quad s_{11} \quad n_{21} \quad s_{21} \quad n_{31} \quad s_{31} \quad N_1. \quad s_1.$$

$$n_{12} \quad s_{12} \quad n_{22} \quad s_{22} \quad n_{32} \quad s_{32} \quad N_2. \quad s_2.$$

$$n_{13} \quad s_{13} \quad n_{23} \quad s_{23} \quad n_{33} \quad s_{33} \quad N_3. \quad s_3.$$

$$s.j. \quad s.1 \quad s.2 \quad s.3$$

$$n.j \quad n.1 \quad n.2 \quad n.3$$

$$C'1 = \sum \left\{ \frac{n_{11} s_{1.}}{N_1.} \right\} - s.1$$

$$C'11 = \sum \left\{ \frac{n_{11}^2}{N_1.} \right\} - N.1$$

$$C'2 = \sum \left\{ \frac{n_{12} s_{1.}}{N_1.} \right\} - s.2$$

$$C'22 = \sum \left\{ \frac{n_{12}^2}{N_1.} \right\} - N.2$$

$$C'3 = \sum \left\{ \frac{n_{13} s_{1.}}{N_1.} \right\} - s.3$$

$$C'33 = \sum \left\{ \frac{n_{13}^2}{N_1.} \right\} - N.3$$

$$C_{12} = \sum \left\{ \frac{n_{11} n_{12}}{N_1.} \right\}$$

$$C_{13} = \sum \left\{ \frac{n_{11} n_{13}}{N_1.} \right\}$$

$$C_{23} = \sum \left\{ \frac{n_{12} n_{13}}{N_1.} \right\}$$

$$(i) \quad c'1 = b_1 c'11 + b_2 c'12 + b_3 c'13$$

$$(ii) \quad c'2 = b_1 c'12 + b_2 c'22 + b_3 c'23$$

$$(iii) \quad c'3 = b_1 c'13 + b_2 c'23 + b_3 c'33$$

$$\begin{array}{ccccccc} \infty & & \infty & & \infty & & \infty \end{array} \quad \text{Sum of totals.}$$

$$b_2 = \frac{c'1 (c'22 - c'23) - c'2 (c'12 - c'13)}{(c'11 - c'13) (c'22 - c'23) - (c'12 - c'13) (c'22 - c'23)}$$

Substituting b_2 in equation (i) above, the value of b_1 is obtained.

The value of b_3 is obtained by the following equation:-

$$b_1 + b_2 + b_3 = 0$$

$$a_1 + m = \frac{s_{1.}}{N_{1.}} - \frac{n_{11} b_1}{N_{1.}} - \frac{n_{12} b_2}{N_{1.}} - \frac{n_{13} b_3}{N_{1.}}$$

$$a_2 + m = \frac{s_{2.}}{N_{2.}} - \frac{n_{21} b_1}{N_{2.}} - \frac{n_{22} b_2}{N_{2.}} - \frac{n_{23} b_3}{N_{2.}}$$

$$a_3 + m = \frac{s_{3.}}{N_{3.}} - \frac{n_{31} b_1}{N_{3.}} - \frac{n_{32} b_2}{N_{3.}} - \frac{n_{33} b_3}{N_{3.}}$$

$$a_4 + m = \frac{s_{4.}}{N_{4.}} - \frac{n_{41} b_1}{N_{4.}} - \frac{n_{42} b_2}{N_{4.}} - \frac{n_{43} b_3}{N_{4.}}$$

$$\text{and finally } \sum_{i=1}^4 (a_i + m) = 4m$$

After obtaining the constants, we now proceed for calculation of sum of squares.

S.S. for constants =

$$(a_1 + m) s_{1.} + \sum (b.j s.j) - \frac{s^2}{N}$$

S.S. (periods) (unadjusted) =

$$\frac{(s_{1.})^2}{N_{1.}} + \frac{(s_{2.})^2}{N_{2.}} + \frac{(s_{3.})^2}{N_{3.}} - \frac{(s)^2}{N}$$

S.S. (factor) (unadjusted) =

$$\frac{(s.1)^2}{N.1} + \frac{(s.2)^2}{N.2} + \frac{(s.3)^2}{N.3} - \frac{(s)^2}{N}$$

S.S. for subclasses - S.S. constants = S.S. interaction.

S.S. constants - period (unadjusted) = S.S. season.

S.S. constants - season (unadjusted) = S.S. period.

This is followed by final analysis of variance.

R E S U L T S.

Table (6)

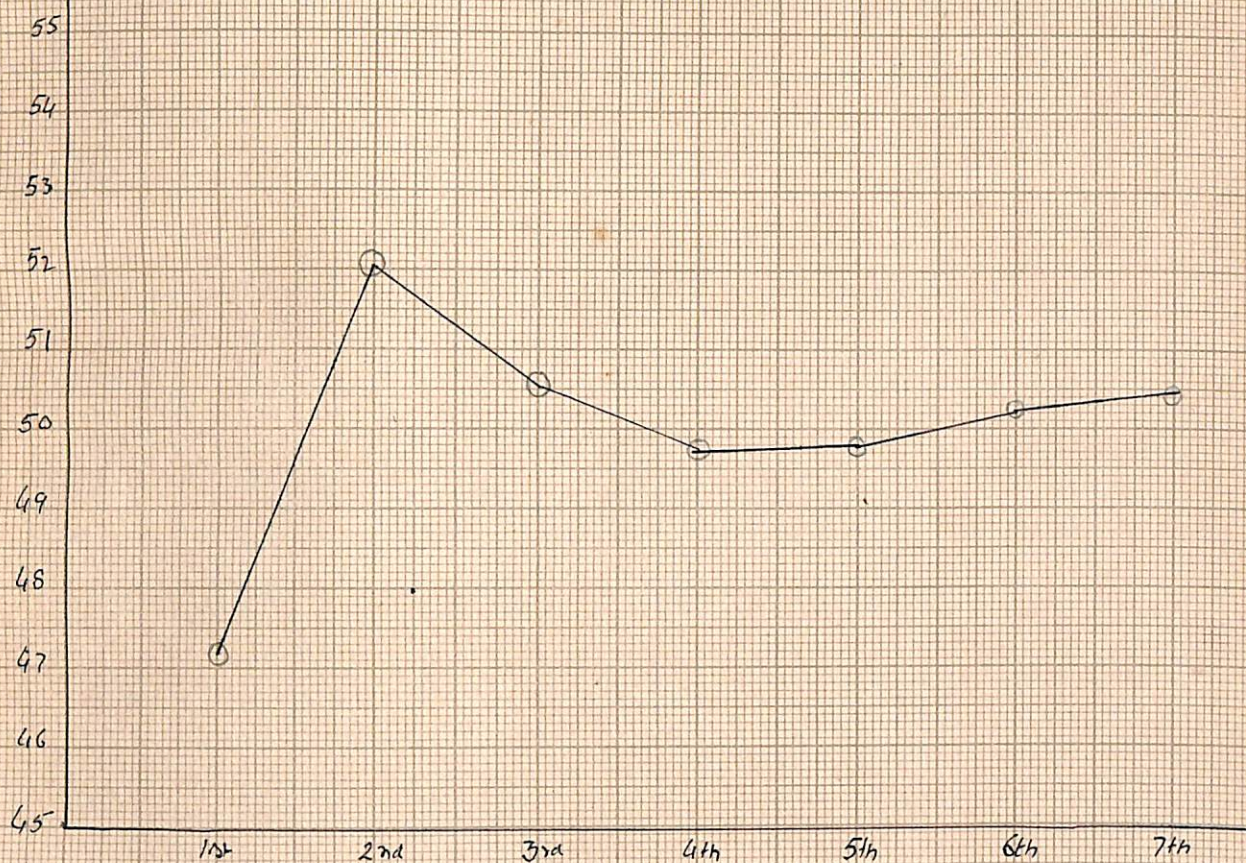
Table showing average birth weight (lbs.),
gestation length and dry period in days.

Breed	Trait	Male	C.V.	Female	C.V.	't'	All	C.V.	S. or N.S.
						value			
Tharpar- kar.	Birth weight	45.46 ±.13	9.7	44.83 ±.13	10	3.17 **	45.19 ±.09	9.73	S
-do-	Gesta- tion length	289.16 ±.36	3.1	283.96 ±1.53	15	70.13 **	286.33 ±.78	11.1	S
-do-	Dry period.						132.58 2.31	58	
Mariana.	Birth weight	52.05 ±.36	15	49.44 ±.32	14	5.38 **	50.78 ±1.02	14	S
-do-	Gesta- tion length	293.94 ±.92	6	293.48 ±.88	5.6	.215	293.71 ±.67	5.8	N.S.
-do-	Dry period.						173.19 ±2.99	38	

S ... Significant.
N. S. ... Non-significant.
** ... Significant at 1% level.

Graph (1) showing effect of calving
sequence on birth weight.

Barium.



Calving sequence.

Table (8)

ANALYSIS OF VARIANCE - EFFECT OF CALVING SEQUENCE -
THARPARKAR.

S. V.	D. F.	M. S.	F.
Between calvings.	7	76.97	.60
Within calvings.	1701	128.98	

Non-significant.

Table (9)

ANALYSIS OF VARIANCE - EFFECT OF CALVING SEQUENCE -
HARIANA.

S. V.	D. F.	M. S.	F.
Between calvings.	6	436.05	4.99**
Within calvings.	931	87.35	

(**) ...Significant at 1%

Table (11)

ANALYSIS OF VARIANCE - EFFECT OF AGE OF DAM ON BIRTH
WEIGHT - THARPARKAR.

S. V.	D. F.	M. S.	F.
Between age groups.	3	9.78	.39
Within age groups.	1717	50.63	

Non-significant.

69 Table (10)

TABLE SHOWING THE SIGNIFICANCE OF DIFFERENCE
OF BIRTH WEIGHT MEANS IN DIFFERENT CALVINGS -
HARIANA.

Calvings compared.	Difference of birth weight means.	"D" values.	Significant or non- significant.
1st & 2nd.	4.80	2.54	*Significant.
3rd & 2nd.	- 1.50	2.61	Non-signifi- cant.
4th & 3rd.	- .79	3.12	-do-
5th & 4th.	.12	3.80	-do-
6th & 5th.	.36	4.59	-do-
7th & 6th.	.26	5.36	-do-
1st & 3rd.	3.30	2.73	*Significant.
1st & 4th.	2.51	3.05	Non-signifi- cant.
1st & 5th.	2.63	3.49	-do-
1st & 6th.	2.99	3.99	-do-
1st & 7th.	3.25	4.14	-do-

(*) significant at 5% level.

Table (12)

ANALYSIS OF VARIANCE - EFFECT OF AGE OF DAM ON BIRTH
WEIGHT - HARIANA.

	S.V.	D.F.	M. S.	F.
Between age groups.	3	353.72	5.24**	
Within age groups.	475	67.46		

(**). Significant at 1% level.

Table (13)

TABLE SHOWING THE AVERAGE BIRTH WEIGHTS IN DIFFERENT
AGE GROUPS.

AGE GROUPS.	THARPARKAR.		HARIANA.	
	Birth weight (lbs.)	S.E.	Birth weight (lbs.)	S.E.
1500 days and below.	44.58	$\pm .44$	48.61	$\pm .84$
1500 - 2000 days.	44.56	$\pm .29$	52.81	$\pm .69$
2000 - 2500 days.	44.93	$\pm .27$	52.73	$\pm .82$
2500 days and above.	44.73	$\pm .28$	53.16	$\pm .65$

-X-

Table (14)

TABLE SHOWING THE SIGNIFICANCE OF DIFFERENCE OF
BIRTH WEIGHT MEANS IN EACH AGE GROUP - HARIANA.

Age group compared.	Difference of means of birth weight (lbs.)	"D" values.	Significant or non- significant.
2nd & 1st.	4.20	2.92	*Significant.
3rd & 2nd.	- .08	2.61	Non-signifi- cant.
4th & 3rd.	.43	2.45	-do-
3rd & 1st.	4.12	3.14	*Significant.
4th & 1st.	4.55	2.78	*Significant.
2nd & 4th.	.43	2.17	Non-signifi- cant.

(*) Significant at 5% level.

Table (15)

TABLE SHOWING THE AVERAGE BIRTH WEIGHTS IN DIFFERENT
SEASONS.

SEASON.	THARPARKAR.		HARIANA.	
	Birth weight (lbs.)	S. E.	Birth weight (lbs.)	S. E.
Summer.	45.98	± .21	50.22	± .55
Rain.	45.54	± .21	50.37	± .54
Winter.	45.09	± .17	51.02	± .41
Spring.	44.93	± .16	51.8	± .50

-X-

Table (16)

ANALYSIS OF VARIANCE - EFFECT OF SEASON OF CALVING
ON BIRTH WEIGHT - THARPARKAR.

	S. V.	D. F.	M. S.	F.
Between seasons.	3	45.22	2.26	
Within seasons.	2319	19.97		

Non-significant.

Table (17)

ANALYSIS OF VARIANCE - EFFECT OF SEASON OF CALVING
ON BIRTH WEIGHT - MARIANA.

	S.V.	D. F.	M.S.	F.
Between seasons.	3	47.30	.82	
Within seasons.	926	57.43		

00

Table (18)

ANALYSIS OF VARIANCE - EFFECT OF SIRE ON BIRTH WEIGHT -
THAPPARKAR.

	S.V.	I	D.	F.	Q	M.	S.	Q	F.
Between bulls.		28				175.0096			9.62**
Within bulls.		1582				18.1752			

[illegible]

(**) Significant at 1% level.

Table (19)

ANALYSIS OF VARIANCE FOR ESTIMATING PATERNAL
HALF-SIB CORRELATION AND HERITABILITY - THARPARKAR.

S.V.	D.F.	Composition of mean square.
Between sires ...	28	175.0096
Within sires ...	1582	18.1752

oo

$n_0 =$ (53.09 average number of off-springs per sire)

$$h^2 = \frac{4 \cdot 6^2 \cdot A}{6^2 \cdot A + 6^2 \cdot B} = 0.56$$

Table (20)

ANALYSIS OF VARIANCE - EFFECT OF SIRE ON BIRTH WEIGHT -
HARIANA.

S. V.	D.F.	M. S.	F.
Between bulls ...	18	374.62	7.44**
Within bulls ...	695	50.36	

-X-

(**) Significant at 1% level.

Table (21)

ANALYSIS OF VARIANCE FOR ESTIMATING PATERNAL HALF-SIB
CORRELATION AND HERITABILITY.

S. V.	D. F.	Composition of mean squares.
Between sires . . .	18	374.62
Within sires . . .	695	50.36

000

n_0 = 35.47 average number of off-springs
per sire.

$$h^2 = \frac{4 \cdot 6^2 \cdot A}{6^2 A + 6^2 B} = 0.60$$

Table (23)

TABLE SHOWING CORRELATION COEFFICIENT BETWEEN GESTATION LENGTH AND BIRTH WEIGHT AND PRECEDING DRY PERIOD AND BIRTH WEIGHT.

B R E E D.		CORRELATION BETWEEN BIRTH WEIGHT AND GESTATION LENGTH. PRECEDING DRY PERIOD.			
Tharparkar	...	.0521	\pm .000235	.0078	\pm .045 (N. S.)
Hariana	...	.47**	\pm .046	-.038	\pm .057 (N. S.)

N.S. ... Non-significant.

(**) ... significant at 1% level.

Table (22)

TABLE SHOWING AVERAGE BIRTH WEIGHTS OF CALVES BORN
IN DIFFERENT YEARS.

Year.	THARPARKAR.			HARIANA.		
	Birth weight (lbs.)	S.E.	C.V.	Birth weight (lbs.)	S.E.	C.V.
1946	47.81	± 0.34	7.12	-	-	-
1947	45.59	± 0.24	6.1	-	-	-
1948	44.58	± 0.41	10.5	-	-	-
1949	47.11	± 0.39	9.45	-	-	-
1950	45.68	± 0.39	9.76	-	-	-
1951	44.02	± 0.42	10.7	55.20	± 1.03	15
1952	46.18	± 0.22	5.18	49.00	± 1.06	15
1953	48.84	± 0.38	8.02	47.47	± 0.78	14
1954	49.13	± 0.38	8.02	47.49	± 0.88	17
1955.	46.61	± 0.32	7.44	48.55	± 0.47	9.5
1956	45.08	± 0.23	5.41	48.23	± 0.40	7.1
1957	43.09	± 0.36	9.24	47.80	± 0.57	7.7
1958	44.58	± 0.20	5.41	46.99	± 0.76	13
1959	41.97	± 0.16	4.60	53.48	± 0.71	13
1960	41.15	± 0.25	7.70	56.77	± 0.81	14
1961	39.88	± 0.18	5.14	50.91	± 0.76	14
1962	45.37	± 0.49	12.65	54.81	± 1.21	16
1963	48.99	± 0.25	6.33	53.00	± 1.12	14

Table (24)

ANALYSIS OF VARIANCE - THARPARKAR - EFFECT OF YEAR
ON BIRTH WEIGHT.

S.V.	D.F.	M.S.	F.
Between years.	17	935.80	70.63
Within years.	2305	13.25	

2322

Significant at 1% level.

Table (25)

ANALYSIS OF VARIANCE - HARIANA - EFFECT OF YEAR ON
BIRTH WEIGHT.

S.V.	D.F.	M.S.	F.
Between years.	12	873.77	18.71
Within years.	917	46.71	

-X-

Significant at 1% level.

Table (27)

ANALYSIS OF VARIANCE FOR EFFECT OF SEASON ON GROWTH
RATE IN THARPARKAR.

S.V.	D.F.	M.S.	F.
Between sexes.	1	4.64	0.78
Between periods.	3	7846.44	131.94**
Interaction.	3	289.20	4.86**
Error.	401	59.47	

-X-

(**) Significant at 1% level.

Table (26)

TABLE SHOWING AVERAGE GAIN IN WEIGHT BY MALE AND FEMALE CALVES OF TWO BREEDS.

Breed.	Factor	0 - 3 months (sex) (Kgs.)	3 - 6 months (Kgs.)	6-9 months (Kgs.)	9 - 12 months (Kgs.)
Tharparkar.	Male.	26.97 ± 1.17	17.05 ± 1.19	13.98 ± 0.89	10.07 ± 1.00
-do-	Female.	21.78 ± 0.89	16.21 ± 0.86	14.05 ± 0.94	6.71 ± 1.31
		(lbs.)	(lbs.)	(lbs.)	(lbs.)
Hariana.	Male.	50.22 ± 6.65	47.35 ± 2.54	53.97 ± 3.03	48.96 ± 3.63
-do-	Female.	43.16 ± 2.08	52.07 ± 2.74	45.88 ± 3.07	47.22 ± 4.21

-X-

Table (28)

TABLE SHOWING ANALYSIS OF VARIANCE FOR EFFECT OF SEX ON GROWTH RATE IN HARIANA.

S.V.	D.F.	M.S.	F.
Between sexes.	1	813.49	2.99
Between periods.	3	122.33	0.45
Interaction.	3	635.84	2.33
Error.	277	273.16	

Table (29)

TABLE SHOWING AVERAGE GAINS IN DIFFERENT SEASONS.

Breed.	Seasons	0 - 3 (Kgs.)	3 - 6 (Kgs.)	6 - 9 (Kgs.)	9 - 12 (Kgs.)
Tharparkar.	Winter.	+ 25.85 - 1.20	+ 17.96 - 1.43	+ 13.69 - 0.93	
-do-	Summer.	+ 33.79 - 1.23	+ 13.93 - 1.11	+ 13.06 - 0.68	
-do-	Rain.	+ 29.84 - 1.24	+ 17.69 - 1.01	+ 15.24 - 1.90	
		(lbs.)	(lbs.)	(lbs.)	(lbs.)
Haryana.	Winter.	+ 45.82 - 2.60	+ 43.74 - 0.92	+ 44.65 - 2.71	+ 47.73 - 4.24
-do-	Summer.	+ 45.77 - 2.17	+ 54.13 - 3.10	+ 55.41 - 3.68	+ 49.95 - 3.44
-do-	Rain.	+ 51.26 - 3.12	+ 48.25 - 4.87	+ 53.33 - 6.35	+ 43.33 - 11.36

~~X-X~~

Table (30)

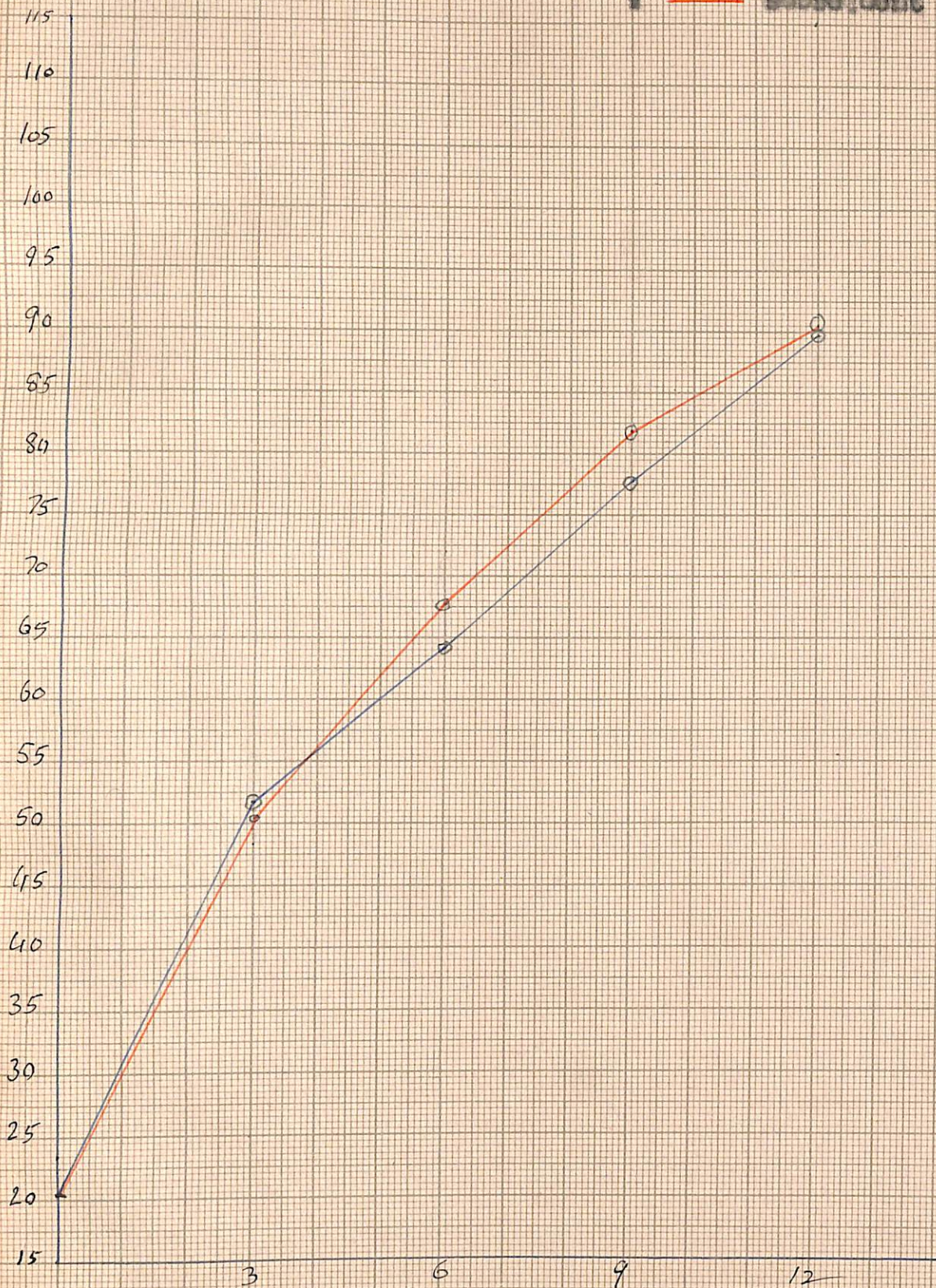
TABLE SHOWING THE SIGNIFICANCE OF DIFFERENCE OF MEANS
OF GAINS BY HARIANA CALVES BORN IN DIFFERENT SEASONS.

Seasons compared.	Difference of means of gains	"D" value.	Significant or not.
Summer and rain.	1.57	5.31	Not significant.
Summer and winter.	5.91	4.29	Significant.
Rainy and winter.	4.34	5.35	Non-significant.

•••••

Graph (5) showing effect of sequence of calving
on growth 2-12.

Tharparker | — First calves.
 | — subsequent calves.



Age in months.

Table (33)

EFFECT OF SEQUENCE OF CALVING ON GROWTH RATE.
TABLE SHOWING AVERAGE GAIN OF CALVES IN 1st
AND SUBSEQUENT CALVING.

Breed.	Calving sequence	0 - 3 months (Kgs.)	3 - 6 months (Kgs.)	6 - 9 months (Kgs.)	9 - 12 months (Kgs.)
Tharparkar.	1st.	+ 31.46 - 1.80	+ 12.69 - 0.75	+ 12.96 - 0.95	+ 7.33 - 1.27
-do-	Subse- quent.	+ 29.74 - 0.85	+ 17.36 - 0.84	+ 14.26 - 0.77	+ 8.32 - 1.13
		(lbs.)	(lbs.)	(lbs.)	(lbs.)
Hariana.	1st.	+ 44.95 - 2.52	+ 51.76 - 3.41	+ 49.91 - 4.59	+ 44.06 - 6.62
-do-	Subse- quent.	+ 48.06 - 1.78	+ 48.60 - 2.20	+ 50.26 - 2.49	+ 50.12 - 2.50

-X-

Table (34)

ANALYSIS OF VARIANCE FOR THE SEQUENCE OF CALVING ON
GROWTH RATE -- HARIANA.

S.V.	D.F.	M.S.	F.
Between calvings.	1	97.86	0.35 N. S.
Between periods.	3	122.33	0.44 N. S.
Interaction.	3	194.99	0.70 N. S.
Error.	277	280.52	

-X-

Table (35)

ANALYSIS OF VARIANCE FOR THE SEQUENCE OF CALVING
ON GROWTH RATE - THARPARKAR.

S.V.	D.F.	M. S.	F.
Between calvings.	1	85.91	1.42 N.S.
Between periods.	3	8004.67	132.20 H.S.
Interaction.	3	137.33	2.27 H.S.
E r r o r.	401	60.55	

-X-

Table (36)

ANALYSIS OF VARIANCE - SHOWING EFFECT OF BIRTH WEIGHT
ON GROWTH RATE - THARPARKAR.

S.V.	D.F.	M.S.	F.
Between above average and below average calves.	1	5.12	0.086 N.S.
Between periods.	3	7048.68	118.80** H.S.
Interaction.	3	316.37	5.33** H.S.
E r r o r.	401	59.33	

-X-

(**) Significant at 1% level.

Table (37)

TABLE SHOWING AVERAGE GAIN OF CALVES CLASSIFIED AS SHOWN.

Breed.	Birth weight of calf.	GAIN IN Kgs.			
		0 - 3	3-6	6 - 9	9 - 12
		months	months	months	months.
Tharparkar.	Above average.	30.06 ± 0.93	15.82 ± 0.77	13.35 ± 0.73	8.93 ± 1.07
-do-	Below average.	27.56 ± 1.37	19.84 ± 1.60	16.14 ± 1.37	5.09 ± 1.26
		(lbs.)	(lbs.)	(lbs.)	(lbs.)
Haryana.	Above average.	46.06 ± 2.05	49.59 ± 2.47	50.24 ± 2.59	44.79 ± 3.40
-do-	Below average.	50.78 ± 0.37	48.86 ± 2.31	50.00 ± 4.07	53.00 ± 4.40
-X-					

Table (38)

ANALYSIS OF VARIANCE - EFFECT OF BIRTH WEIGHT AND GROWTH RATE -
HARIANA.

S.V.	D.F.	M.S.	F.

Between above average and below average calves.	1	503	1.81 N. S.
Between periods.	3	122.33	0.44 N. S.
Interaction.	3	240.98	0.87 N. S.
Error.	277	278.56	

-X-

Table (39)

ANALYSIS OF VARIANCE FOR PATERNAL HALF-SIB CORRELATION
AND HERITABILITY OF GAIN AT ONE YEAR - THARPARKAR.

S.V.	D.F.	Composition of mean squares
Between sires.	5	409.88
Within sires.	56	104.26

$n_o = 12.19$ Average number of progeny
per sire.

$$h^2 = \frac{4 \cdot 6^2 \cdot A}{6^2 \cdot A + 6^2 \cdot B} = .776$$

Table (40)

ANALYSIS OF VARIANCE FOR PATERNAL HALF-SIB CORRELATION
AND HERITABILITY OF GAIN AT ONE YEAR - MARIANA.

S.V.	D.F.	Composition of mean squares.
Between sires.	2	741.52
Within sires.	45	861.70

$n_o = 15.11$ Average number of off-springs
per sire.

$$h^2 = \frac{4 \cdot 6^2 \cdot A}{6^2 A + 6^2 B} = .44$$

Table (41)

TABLE SHOWING LIVE GROWTH, GAIN IN WEIGHT AND
GAIN AS PER CENTAGE OF PREVIOUS WEIGHT OF
THARPARKAR & HARIANA.

MONTH.	THARPARKAR.			HARIANA.		
	Live weight (lbs.)	Gain in weight (lbs.)	Gain as %age of previous weight.	Live weight (lbs.)	Gain in weight (lbs.)	Gain as %age of previous weight.
Birth weight.	49.37	-	-	53.12	-	-
1st.	90.22	40.85	82.74	73.30	20.18	37.99
2nd.	104.57	14.35	15.91	88.48	15.18	20.71
3rd.	114.33	9.76	9.33	101	12.52	14.15
4th.	127.25	12.92	11.30	116.39	15.39	15.24
5th.	139.61	12.36	9.71	134.05	17.66	15.17
6th.	151.84	12.23	8.76	150.57	16.52	12.32
7th.	163.15	11.31	7.45	166.75	16.18	10.75
8th.	174.72	11.57	7.09	183.01	16.26	9.75
9th.	181.19	6.47	3.70	201.27	18.26	9.98
10th.	187.24	6.05	3.34	215.77	14.50	7.20
11th.	193.38	6.14	3.28	233.90	18.13	8.40
12th.	229.79	36.41	16.81	247.32	13.42	5.74

-X-

Chapter V.

DISCUSSION

Chapter V.

EFFECT OF SEX ON BIRTH WEIGHT:-

The average birth weight of male, female and all calves of Tharparkar was found to be 45.46 ± 13 lbs., $44.88 \pm .13$ lbs. and $45.19 \pm .90$ lbs. respectively with a coefficient of variation of 9.7%, 10% and 9.73% respectively. The average birth weight of male, female and all calves of Mariana herd was $52.04 \pm .36$ lbs., $49.44 \pm .32$ lbs. and 50.78 ± 1.02 lbs. with a coefficient of variation of 15%, 14% and 14% respectively (vide table 6). Males were significantly heavier than females. This is by virtue of their genetic make and secondly due to influence of hormones (Hammond, 1955). This is in agreement with findings of Dinkauser et. al. (1944), Paim (1947), Veiga, Chiffi et. al. (1948), Choudry and Sinha (1951), Askar and Ragab (1952), Anantakrishnan and Lazrus (1953), I.V.R.I. Annual Report (1955-56), Pattabhiraman (1957), Kohli and Suri (1957), Singh and Desai (1959), Roy and Goswami (1960), Singh and Dutt (1961), Patra and Desai (1962).

EFFECT OF SEQUENCE OF CALVING:-

The sequence of calving had no significant effect on birth weight of calf in Tharparkar herd, but in Hariana it was found to be significant at 1% level. (vide tables 7, 8 and 9).

The findings of Tharparkar herd confirm with those of Kahlil and Suri (1957) and Lall and Rizvi (1959).

The results of Hariana is in agreement with those of Ragab and Askar (1952), Ananta Krishnan and Lazrus (1953), Suchanek (1962), Stegenga (1962), Ridler et. al. (1963).

Table 10 shows the significance or otherwise of difference of mean birth weights of calves born in different calvings in Hariana herd.

The calves born in first calving are smaller than the calves of other calvings. They differ significantly from calves born in second and third calvings. There ^{is} increase in birth weight of calves, though insignificant, from 4th calving to 7th calving.

The calves of first calving are usually smaller than of subsequent ones because of the competition for nutrients between the maternal tissues which are not fully developed yet and the growing foetus (Hammond, 1955). Secondly they experience a restricted growth in utero leading to smaller birth weight (Dickinson, 1960).

This finding is in concurrence with those of Eckles (1919, 1920), Fitch et. al. (1924), Tyler et. al. (1947), Venge (1948), Dinkauser et. al. (1944), Hewit (1951), Suchanek (1962) and Ridler et. al. (1963).

The calves of first calving in Tharparkar are smaller than subsequent ones (except those of second calvings) the difference, however, being insignificant. Similarly the increase in birth weight from 3rd to 5th calving is insignificant. This deviation may be a breed characteristic. It may also be probably due to an insignificant increase in size of the dam from calving to calving. The size of the dam has been reported to influence the size and hence weight of the calf at birth (Eckles, 1919), Knapp et. al. (1942) and Venge (1948). A perusal of table 7 shows that calves of second calving of Hariana herd are the heaviest and those of 3rd, 6th and 7th approach very nearly the average of the herd.

With earlier reviews in mind that heavier calves grow rapidly, attain heavier weights and are able to withstand adverse conditions, one can safely embark on the conclusion and commend the selection of calves with heavier weights for breeding and also as work animals. Since the cost of

raising young stock to their productive age is higher than their market value, selection on this basis would reduce the uneconomical unproductive period and would permit greater attention and care to the upbringing of the promising few.

EFFECT OF AGE OF DAM:-

The age of dam was found to have no significant effect on the birth weight of calf in Tharparkar herd, but in Hariana herd the same was found to be significant at 1% level (vide tables 11, 12 and 13).

The observation in Tharparkar concurs with the findings of Anantakrishnan and Lazrus (1953). The results in Hariana confirm with those of Eckles (1919), Knappa et. al. (1942), Kudalicka (1949), Lasely, Day and Comfort (1961), Singh and Dutt (1961) and Stegenga (1961).

Table 14 shows the significance of difference of mean birth weights of calves born in different age groups. In the present method of classification of age groups, it can be visualised from table 13 calves from younger dams have lesser birth weights. This is so because the birth weight is more an expression of size, weight and physiological

condition of the dam rather than the foetus, although the genetic composition of the later does have some affect.

The effect of age of dam is analogous to that of sequence of calving. In a normal productive life of an animal with increase in chronological age, the physiological age also increases. The increase in size of the dam and with it the age of dam, probably, does not contribute much towards increasing the weight of the unborn calf - hence this nonsignificance of calving sequence and with it the age of dam on the birth weight in case of Tharparkar herd.

EFFECT OF SEASON OF CALVING:-

The season of calving was found to have no significant effect on birth weight of calves in both the breeds (vide tables 16 and 17).

These findings are similar to those of Knapp and Lambert (1944), Askar and Ragab (1952) and Petrovic (1956).

The probable causes for this may be that the rigours of the seasons were not severe to impress their effect on birth weight or that the animals were acclimatized.

EFFECT OF SIRE:-

The sire was found to affect the birth weight of calf significantly in both the breeds (vide tables 18 and 20). These findings are similar to those reported by Ragab and Askar (1951), Ananta-krishnan and Lazrus (1953).

On the contrary, Paim (1947) and Kohli and Suri (1957) found that sire did not affect the weight of calf at birth.

These findings indicate that the birth can be improved by providing good bulls, since this trait has been found to be highly heritable as well. It has been reported by Ragab and Askar (1951) that the sire influences the gestation length as well. These facts coupled with the observation of a positive correlation between gestation length and birth weight justify the provision of bulls, in breeding programmes, of proven merit in providing better calves.

EFFECT OF YEAR:-

The effect of years on birth weight was found to be highly significant in both breeds. Heaviest calves were born in 1954 in Tharparkar herd and in 1960 in Hariana herd. In Tharparkar, calves above average for the herd were born in the years 1946-50, 1952-55 and in 1962-63. (vide table 22).

EFFECT OF GESTATION LENGTH:-

The average gestation length of male, female and all calves in Tharparkar herd was found to be $289.16 \pm .36$, 283.96 ± 1.53 and $286.33 \pm .78$ with a coefficient of variation of 3.1%, 15% and 11.1% respectively. Males were carried for a significantly longer period than females (vide table 6).

The average gestation length of male, female and all calves in Mariana herd was found to be $293.94 \pm .92$, $293.8 \pm .88$ and $293.71 \pm .67$ with a coefficient of variation of 6%, 5.6% and 5.8%. No significant difference was observed in gestation length of male and female calves (vide table 6).

The average figures for Tharparkar coincides with that of Choudry and Sinha (1951) in Tharparkar herd observations similar to that of Tharparkar. With regard to gestation length of male and female calves were recorded for by Jordao and Assis (1950), Choudry and Sinha (1951), Ragab and Askar (1951), Kohli and Suri (1951) and Brakel, Rife and Salishury (1952).

Ragab and Askar (1951) and Singh et. al (1958) recorded similar observations as for Mariana herd in the present study. The average of gestation length are slightly larger than those recorded by other workers.

The correlation between gestation length and birth weight was $.0521 \pm .00024$. This was found to be nonsignificant (vide table 23).

A positive significant correlation of $0.47 \pm .046$ was observed in Haryana herd (vide table 23).

Observations similar to that in Tharparkar herd were observed by Ragab and Asker (1951), Choudry and Sinha (1951), Anaktakrishnan and Lazrus (1953), Brakel, Rife and Salisbury (1952), Singh and Dutt (1961) and Singh and Ray (1961).

The observations of Haryana herd concurs with that of Ragab and Askar (1951), Anaktakrishnan and Lazrus (1953), Brakel, Rife and Salisbury (1952).

A positive correlation indicates that heavier calves of either sex need a longer time to complete their prenatal growth. Therefore, selection driving at an increase in birth weight should aim at increasing the gestation length. It has been observed that sire affects the gestation length (Ragab and Asker, 1951) and also the weight of calf at birth (Ragab and Asker, 1951, and Anaktakrishnan and Lazrus, 1953).

Therefore, sires should be so selected in a breeding programme which would affect the gestation length to an optimum level, so that calves of average birth weight for the herd or more are born at successive calvings.

The deviation in Tharparkar herd may be attributed to breed difference.

REGRESSION OF BIRTH WEIGHT ON GESTATION LENGTH:-

The regression of birth weight on gestation length was found to be $.00788 \pm .0048$ lbs. in Tharparkar herd and $.12 \pm .061$ lbs. in case of Hariana herd. This indicates that for every extra day of gestation length there is an increase of $.0078$ lbs. in birth weight of calf in Tharparkar and $.12$ lbs. in case of Hariana. These observations are much below that observed by Braude and Walker (1949) and DeFries (1959).

The length of gestation may be shortened or increased by selection. The magnitude of change that is possible in any number of generations can only be determined by experimentation. Experimentation is also necessary to evaluate the magnitude of any deleterious effects that may follow modifications of gestation length. The differences in the observations of Tharparkar and Hariana may be breed characteristics or due to any sampling errors.

EFFECT OF PRECEDING DRY PERIOD:-

The correlation between preceding dry period and birth weight in Tharparkar herd was found to be $.0078 \pm .045$. This is non-significant (vide table 23). A non-significant correlation of $-.038 \pm .057$ was observed in Hariana herd.

The observation in Tharparkar is similar to that of Uman Yu (1933) and Krizenecky and Kudlicka (1944). Combery and Cerovsky (1956) obtained a positive correlation of $+.5354$ for dry periods of less than 30 days. They found that a longer period was not related to an increase in birth weight.

The differences in Tharparkar and Hariana herd may be due to sampling errors.

HERITABILITY ESTIMATE:-

The heritability of birth weight in Tharparkar and Hariana herd was found to be 0.56 and 0.60 respectively (vide tables 19 and 21). The heritability of birth weight of Tharparkar was higher than that obtained by Singh and Desai (1958) in Tharparkar herd and that of Askar and Ragab (1952), Batra and Desai (1962) and lesser than that of Lasley, Day and Comfort (1961).

The heritability estimate in Hariam is almost similar to that of Lasley, Day and Comfort (1961) and is higher than other observations of workers mentioned above.

The high heritability obtained may be due to any sampling errors, which is magnified to 4 times in paternal half-sib method. The high heritability indicates that genetic contribution by the bulls is high and improvement can be brought by selection of animals with higher birth weight for breeding purposes.

Summing up, the analysis of the factors affecting the birth weight in Tharparkar indicates that the only possible way of bringing about improvement in birth weight is by use of superior bulls proved to produce better calves and by providing good nutritious diet during the period of steaming up. This is possible because the trait is highly heritable and also as reviewed earlier the sire has been found to affect the gestation length. (This later aspect has not been studied in this present work).

In Hariana herd, several factors have been found to affect the birth weight, viz. sire, age of dam, sequence of calving, a positive correlation between gestation length and birth weight. Besides the trait has been found to be highly heritable.

The fact that the sire influences the birth weight and secondly the significant positive correlation between gestation length and birth weight denotes that improvement can be brought about by selecting sires which produce calves of average or heavier birth weight for breeding purpose and also by improving factors which affect gestation length.

EFFECT OF SEX ON GROWTH RATE:-

No significant difference in growth rate was observed on an average for the whole one year, between two sexes of two breeds under study. This is similar to observations of Rollins and Guilbert (1958) who studied growth rate in beef calves upto 8 months of age; and also that of Gregory, Blunn and Baker (1950), who studied growth upto weaning in beef calves.

Heavier growth rate of males were observed by Hammond (1955), Thomas, Marlow and James (1958), Morrison (1957), Koch et. al. (196), Makela (1960) and Ghoneim and Rafat (1960).

The insignificant difference in the growth rate of male and female calves of the two breeds on an average for the whole year is mostly due to chance, since the number of observations were less.

A perusal of tables 26 and 27 shows that in Tharparkar herd there is significant difference in the growth rate between periods and also the interaction is highly significant whereas in the Hariana herd there was no significant difference between periods and the interaction as well was also nonsignificant (vide table 28).

The difference in the growth of male and female calves atleast in periods confirms with the general physiological principle that males are heavier at any age than females. Firstly this is due to the direct effect of sex, due to differences in the genetic make up (Hammond, 1955) and indirectly due to the influence of sex hormones.

The deviation in case of Hariana is probably due to sampling errors.

EFFECT OF SEASON OF BIRTH ON GROWTH RATE:-

The season of birth was found to have no significant effect on growth rate in Tharparkar herd, whereas in Hariana the effect was found to be significant at 5% level (vide tables 29, 30 and 31). The growth rate was studied upto 9 months only in case of Tharparkar herd because of the seasons mentioned in chapter iv under the appropriate heading.

The observations pertaining to Haryana herd were similar to those of Phillips (1946), Thomas and Marlow (1958), Holl and Sramek (1959), Suchanek (1961), Ridler (1963).

The observations in Tharparkar are probably due to less number of observations. However, between periods there is a significant difference in the growth rate of calves born during different seasons. The interaction is also highly significant. This indicates that calves born in different seasons gain significantly different weights in different periods. Table 29 shows that calves born in summer gained greater weights in first three months than that of calves born in other two seasons. They gained lesser weight in second and third quarters compared to gain in weight of calves born in winter and rainy seasons in similar periods. The overall gain in three quarters of calves born in different seasons is, however, insignificant.

In Haryana herd, it was observed that summer-born calves gained more during the period of one year. Their growth in first quarter was, however, found to be less than that of calves born in winter and rainy season. In subsequent quarters, summer-born calves gained more than the calves born during other seasons (vide table 30).

This appears to be quite logical.

The initial impulse to grow in calves is strong enough to minimise the effect of environment (Brody, 1945). The dam provides to the calf maternal environment till weaning in which period the calf is subjected to external environments. This maternal environment provides a sort of protectiveness to the calf.

Keeping in mind these aspects, we can now visualise the growth of the calves. The summer-born calves, like other calves, had initial impulse to grow (The self-accelerating phase of growth - Brody, 1945) upto four months, when this impulse begins to dwindle. They had then a favourable period, of rainy and winter season, to grow through, during which period the quality of fodder is good and so also the quantity. The calves thus had the benefit of having enough nourishment from their mother during their suckling period and abundant fodder during the remaining periods.

The calves born in other seasons, however, had initial greater gains (vide table 29), but were less fortunate as they had to grow through rigours of summer season at a time when the initial impulse to grow would have dwindled away.

The minimum gain of summer-born calves in the first three months of life may be attributed to diminished milk yield of the cows in summer due to "voluntary anorexia" to which the animals resort to, in order to minimise the "heat load", (Hammond, 1955). Further, there may have been a direct effect on the growth of calf itself.

These observations are a pointer to the fact that it is possible to improve the weight gain by providing ameliorative measures as far as practicable.

The deviations observed in Tharparkar in respect of the gain for 9 months may be due to sampling errors. The seasons might have favourable at certain periods and unfavourable at other periods, so that 'between periods' the gain was significantly different, but on the whole there was no significant difference in gain in weight.

The breeding programmes should, therefore, be so adjusted that calves will have a favourable environments of feed, fodder and climatic conditions, to grow through from their fourth month of life onwards. This does not mean that the initial period does not require good management. It only indicates that growth can be improved during the period after fourth month by providing better environment, since the maternal environment would have removed by then or even earlier.

Effect of calving sequence on growth rate:-

There was no significant difference in the growth rate of calves born during first calvings and those of subsequent calvings in Tharparkar and Hariana herd (vide tables 34 & 35).

Similar observations were reported by Ridler et. al. (1963).

In Tharparkar herd, it was observed that there was significant difference in the growth rate of calves of first and of subsequent calvings in certain periods of a year of growth. The interaction was non-significant.

Table 33 shows that calves of first calvings in Tharparkar herd gained more during first three months than those of subsequent calvings, in the remaining periods than the calves of first calving.

Similar observations have been reported by Rollins and Guilbert (1954) who observed that calves of first calvings gained more from fourth to eighth month. The calves of first calvings, as suggested by Dickinson, 1960, experienced restricted growth in utero, leading to smaller birth weights and, therefore, after birth they grow at a faster rate -- a form of compensatory growth.

The non-significance observed in Hariana herd, similar to that of Ridler et. al. (1963) may be due to breed differences of sampling errors.

The calves of first calving which gain faster than calves of subsequent calvings must be provided a better nourishment during their period of faster growth so that maximum gain is obtained. Since the growth of calf during the earlier stages of life is dependent on the lactating ability of the cow, the dams should be well cared for so that maximum growth of calves is obtained.

It, therefore, does not come as a surprise that most of the factors which have been associated with increased weight gains are identical with the factors related high yields in dairy cattle. Therefore, by bringing about an improvement, by selection, in lactating ability the growth rate of calves can also be significantly improved.

EFFECT OF BIRTH WEIGHT ON GROWTH RATE:-

There was no significant difference in the growth rate of calves, with birth weights above and below the average of herd in Hariana herd. There was no difference in "between periods" and also the interaction was non-significant (vide table 37).

In Tharparkar it was observed that there was no significant difference on the whole in a period of one year between the two categories of calves (vide table 36). There was, however, significant difference between periods and the interaction was also highly significant.

The observations of Hariana were similar to those of Abelin and Ritter (1960).

The significant periodical difference in the weight gain observed in Tharparkar herd was similar to that of Makela (1960) and Ridler (1963) who observed fluctuations in weight gain at different periods.

Table 37 shows that calves with above average birth weight gained more in first and fourth quarter, whereas below average calves gained more in second and third quarters. The overall gain was, however, insignificant between the two categories of calves.

Since there is no significant overall gain, but only in certain periods, it would be a good proposition to provide calves better nutrients during their periods of increased growth. As the calves are dependent on the lactating ability of the cow in the initial periods of growth, the arguments discussed under "Effect of calving sequence" can be extended to this as well.

HERITABILITY OF GAIN AT ONE YEAR AGE:-

The heritability of gain at the end of one year was found to be 0.776 in Tharparkar herd and 0.44 in Hariana herd. This high heritability may be due to smaller number of observations under study or that the sires used were of superior type or due to sampling errors which is magnified four times in paternal half-sib method. However, the heritability indicates that improvement in gain in live weight can be brought about by selection of individuals.

THE GROWTH CURVE:-

Table 41 shows the weight gained by two breeds at monthly intervals. It is observed from this table that calves of both breeds gained maximum in first month of life and then onwards there was gradual decline in the weight gained in Tharparkar herd only. In Hariana herd, the growth curve does not follow the usual pattern as observed by Bartlett and Jameson (1932), Cambel and Flux (1952) and that observed at I.V.R.I., Izatnagar (1956-57) and that of Ridler et. al. (1963). These fluctuations in growth may be due to variation from place to place and other environmental factors like availability feeds and fodder, prevalence of any diseases, climatic conditions etc. which affect

growth rate either directly or indirectly through the dam. The deviation observed in the present study may be due to sampling errors, since the number of observations were not much or due to any of the causes mentioned above.

The growth curve study serves as a check on the management practices of the farm concerning not only the youngest stock but also that of adult stock since the dams affect the growth of the calves by virtue of their lactating ability.

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Chapter 6.

S U M M A R Y

Chapter 6

SUMMARY.

The factors affecting "birth weight" and "rate of growth upto one year of age" have been studied in Tharparkar and Hariana herds stationed at Government Livestock Farms at Patna and Dumraon respectively. The factors studied were effect of sex, calving sequence, age of dam, season of birth, sire, year, gestation length and preceeding dry period on birth weight and also the heritability estimate for both Tharparkar and Hariana herds.

The effect of sex, season of birth sequence of calving and birth weight on growth rate was studied for both the breeds. The heritability of gain at one year and the growth curves for both the breeds were also studied.

The birth weight of male, female and all calves was found to be $45.69 \pm .13$ lbs., $44.83 \pm .13$ lbs. and $45.19 \pm .09$ lbs. in Tharparkar and $52.05 \pm .36$ lbs., $49.44 \pm .32$ lbs. and 50.78 ± 1.02 lbs. in case of Hariana.

Males were significantly heavier than females. The effect on birth weight of season and sequence of calving, age of dam, the correlation between gestation length and birth weight and the correlation between preceeding dry period and birth weight were all found to be non-significant in Tharparkar.

The correlation between gestation length and birth weight and the correlation between preceeding dry period and birth was found to be $.0521 \pm .00024$ and $.0078 \pm .045$. This is insignificant and indicates that birth weight cannot be improved by modifying these factors.

The regression of birth weight on gestation length was found to be $.0078 \pm .0048$ in Tharparkar and $0.12 \pm .061$ in Hariana. This was non-significant.

The effect of sire and years was found to be highly significant. The heritability estimate was found to be .56. Improvement can, therefore, be brought about by selecting superior sires which consistently produce heavier calves and also by selecting calves with heavier weights as future breeding animals.

In Hariana, the effect on birth weight of calving sequence, age of the dam, sire, year and the correlation between gestation length and birth weight were all found to be significant at 1% level.

The calves of second calvings were heavier than calves of other calvings, though not significantly, (excepting those of first calvings). Since the sire has been found to affect the birth weight of calf significantly, superior sires may be used for producing heavier calves during second calving and such animals may be used for breeding purposes.

The significant positive correlation of $0.47 \pm .046$ (significant at 1% level) denotes that birth weight can be increased by modifying the factors affecting gestation length favourably.

The heritability of birth weight was found to be 0.60. This signifies that birth weight can be improved by selection of superior sires and calves of heavier birth weights as future breeding animals.

GROWTH RATE - THARPARKAR:-

In Tharparkar herd, it was found that there was no significant affect of sex, season of birth, calving sequence and the birth weight on rate of growth on an average for a period of one year of age. However, there was significant affect of sex, season of birth and the birth weight on weight gain in different periods (one year was divided into 4 periods of three months each).

The interaction period X factor (sex, season of birth and birth weight) was also found to be highly significant.

These observations denote that overall improvement can be affected by providing the calves a good environment of feeding, management etc. during the periods of increased growth, so that the maximum capacity to grow is exploited to the full in the case of all female calves and the few selected male calves earmarked for breeding. If this increased growth happens to be during the period of suckling, greater attention should be paid towards the feeding of the dam as well, since the milk yield of the dam has a direct bearing on the growth rate of calves.

The affect of sequence of calving had no significant affect on the growth rate for a period of one year of age, nor on the weight gain during different periods. The interaction (calving sequence X period) was also non-significant.

The heritability of gain in weight at the age of one year was found to be .776 on the basis of 62 observations. As it is based on few observations, it can be said with reservation that growth rate can be improved by selection but not to the magnitude obtained in this study.

GROWTH RATE - HARIANA:-

There was no significant affect of sex, sequence of calving and birth weight on rate of growth upto one year of age in Hariana herd. The gain in weight in different periods and the interaction (factor X period) was also found to be nonsignificant.

The effect of season of birth on growth has been studied upto 9 months of age and was found to be significant at 5% level. The difference in gain in "between periods" and the interaction (season X period) was non-significant.

The summer-born calves were found to have gained more weight than calves born in other seasons (The probable reasons have been enumerated in chapter 5).

This signifies that greater gain can be effected by providing ameliorative measures, as far as practicable, to minimise the affect of summer on the dam and also any direct or indirect effect on the calf itself. This factor together with good feeding and management during favourable periods can be synergized to boost up gain in weight. The dams should also be provided with good feeds and fodder, on recommended lines, as the growth of the calf is a reflection of the lactating ability of the dam.

The heritability of gain in weight at the age of one year was found to be .44. As this was based on smaller number of observations, it can be said, rather guardedly, that growth rate can be improved by selection though not the magnitude obtained in the present study.

THE GROWTH CURVE:-

The growth curve of Tharparkar and Bariana shows that the calves gained maximum weight (82.74% in Tharparkar and 37.99 in Bariana) during their first month of life and then onwards there were fluctuations. These may be due to smaller number of observations under study and may also be due to the climatic variations, prevalence of diseases and management practices etc. It would be worthwhile if further studies are conducted on an exhaustive number of observations. It would then be possible to have "standard curves" for that particular place, with which one compare the performance of future animals and also of same breed at other places having similar management and environments. However, in these circumstances as well, there is always every possibility of variations in the

environment which may modify the shape of growth curve. Within limitations, "standard growth curves" are useful as a check on the performance of the animals in the herd.

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