GENETIC STUDIES ON GROWTH OF HARIANA CATTLE

AT

INDIAN VETERINARY RESEARCH INSTITUTE
IZATNAGAR

By

SURESH BALASAHEB GOKHLE
B. V. Sc. & A. H.
Post-Graduate College of Animal Sciences,
INDIAN VETERINARY RESEARCH INSTITUTE,
IZATNAGAR (U. P.)

Thesis
Submitted to the Agra University, Agra,
in partial fulfilment of the requirements for the Degree of
MASTER OF VETERINARY SCIENCE
IN
ANIMAL GENETICS & BREEDING

APRIL, 1970

GENETIC STUDIES ON GROWTH OF HARIANA CATTLE

AT

INDIAN VETERINARY RESEARCH INSTITUTE
IZATNAGAR

By

SURESH BALASAHEB GOKHLE
B. V. Sc. & A. H.
Post-Graduate College of Animal Sciences,
INDIAN VETERINARY RESEARCH INSTITUTE,
IZATNAGAR (U. P.)

Thesis
Submitted to the Agra University, Agra,
in partial fulfilment of the requirements for the Degree of
MASTER OF VETERINARY SCIENCE
IN
ANIMAL GENETICS & BREEDING

APRIL, 1970

Dr. O.B. Tandon,
B.Sc. (Agri.), M.A., M.Sc., Ph.D.(Iowa),
Head, Division of Animal Genetics,

Indian Veterinary Research Institute,
IZATNAGAR (U.P.)

Dated the 25 April, 1970.

Certified that the research work contained in this thesis entitled "Genetic Studies on Growth of Hariana Cattle at Indian Veterinary Research Institute, Izatnagar" by Shri S.B. Gokhale is an original work carried out by him under my supervision and guidance.

O.B. Tandon

(O.B. TANDON)

ACKNOWLEDGEMENTS

The author is deeply indebted to his guide, Dr. O.B. Tandon, B.Sc. (Agri.), M.A., M.Sc., Ph.D. (Iowa), Head, Division of Animal Genetics, Indian Veterinary Research Institute, Izatnagar, for suggesting the problem, constant and valuable guidance, constructive criticism both during assessment of the data and preparation of manuscript.

Thanks are also due to Shri A.N. Gautam of Farm Animal Genetics Section and Shri G.L. Koul, Ph.D. Scholar, Indian Veterinary Research Institute, Izatnagar, for their cooperation during collection of data and encouragement at all the times.

The author is thankful to Shri B.S. Sharma, Assistant Statistician, Indian Veterinary Research Institute, for his help in statistical analysis.

Thanks are also due to the Director, Indian Veterinary Research Institute, Izatnagar for awarding the financial assistance in the form of Merit Scholarship to enable carrying out this investigation.

C O N T E N T S

INTRODUCTION

A definition of growth seems to be necessary for its quantitative study but defining growth has not been easy. Schloss (1911), Hammett (1936), Brody (1945), Maynard (1947) and Hammond (1952) and a number of other workers have all attempted to give a descriptive and functional definition of growth.

Accordingly growth is an irreversible, correlated and coordinated increment in the mass of the body in a definite interval of time in a way that is characteristic of the species, and until the mature size has been reached. True growth in effect is an expression of the increase in the weight of the organs and of the structural tissues. As against this development is considered to be a change in body confirmation, shape and function.

Retarded growth delays puberty and thereby the length of the productive life of an animal. There is considerable evidence that poor growth adversely affects even the productivity of cattle. Consequently assessment of growth in terms of body weight assumes considerable economic importance and optimum growth of the young ones is a matter of constant concern for all breeders, owners and research workers. Growth is known to be affected by

hereditary as well as by a number of known environmental factors. In addition to these known factors there are, in all probability, a large number of still unknown factors which affect growth and body weight of our cattle. Efforts are continuously being made, therefore, to ascertain the relative effects of these with a view to utilize that information for improvement of their growth rates.

Hariana is one of the most important breeds of cattle for India. It is spread over the entire northern part of the country and possibly over a large part of even central India. The present work was, therefore, undertaken on this breed. Various factors which affect body weight and growth were to be studied to ascertain their relative importance and it was intended that some guide lines for optimum achievable body weights and growth rates could be arrived at as a result of this study. Body weights at birth, 3 months, 6 months, 9 months, 12 months, 18 months, 24 months and 36 months were chosen to be studied.

REVIEW OF LITERATURE

BIRTH WEIGHT

Birth weight and the factors affecting it have been studied in various breeds by many workers. The pertinent work is reviewed hereunder.

Uman (1933) observed an average birth weight of male Red German calf to be 32.2 kg and that for female to be 31.8 kg. Birth weights of Holstein, Brown Swiss, Ayrshire, Guernsey and Jersey were studied by Ragsdale (1934). These were 40.9 kg, 36.3 kg, 32.7 kg, 29.5 kg and 24.1 kg, in females and 43.2 kg, 38.6 kg, 36.4 kg, 32.3 kg, and 27.3 kg for males, respectively. The findings of Groenewald (1935), Palicte (1938), Tyler, Chapman and Dickerson (1947), Williard (1948) and Kassab and Stegenga (1964) are more or less in agreement with Ragsdale.

Venge (1948) reported birth weights of Swedish Red and White and Red Danish Dairy breed to be 40.0 kg and 40.0 kg respectively. Vogel (1952) reported average birth weights of Spotted Mountain, Spotted Mountain German, Red and Black Pied Lowland cattle as 40.0 kg, 40.0 kg and 42.0 kg respectively. Tantawy (1948) studied birth weight and growth of Egyptian cattle. Weight at birth, irrespective of sex of calf was 26.0 ± 4.0 kg. Rognoni and Pasti (1959)

found birth weight in Friesian calves to be 33.4 kg and daily weight gain of 856 gm. Suchánek (1961) recorded birth weight of 43.6 kg in Czechoslovak Red Spotted cattle. Peker and Özdural (1962) reported birth weight in Karacabey-Montafon calves to be 38.4 ± 0.9 kg. Alim (1964) found average birth weight of all calves in Kenana cattle to be 22.7 kg, males being 1.7 kg heavier than females. Luna (1964) reported birth weights for males of Santa Gertrudis, Brahman and Criollo cattle to be 32.3 kg, 28.2 kg and 29.6 kg respectively. Muhamedgaliev et al. (1966) reported birth weight of Ala Tau cattle to be 35.1 kg in males and 33.5 kg in females, while their crosses with Jersey weighed 27.8 kg and 25.9 kg respectively.

Palicte (1938) also studied Ayrshire-Nellore grades and reported an average 25.4 kg birth weight for first generation of grades. In fourth generation of grading up, the birth weight decreased to 19.5 kg. He also reported birth weights of Red Sindhi and of milking Short-horn cattle to be 18.7 kg and 33.2 kg respectively. Muñoz and Rigor (1940) reported similar findings in Red Sindhis; at birth males weighed 19.2 ± 0.3 kg and females 18.3 ± 0.3 kg. Tyler, Chapman and Dickerson (1947) found difference in birth weights of inbred and outbred stock of Holstein. They reported that outbred calves weighed 42.2 kg and inbred

calves weighed 38.9 kg. Outbreds were heavier at birth than inbreds. Beker and Quesenberry (1944) showed superiority of crossbreds (Hereford X Short-horn) in birth weight (35.0 kg) over purebreds (33.7 kg). Muñoz (1964) studied crossbred heifers resulting from reciprocal crossings between Brahman, Santa Gertrudis and Criollo and reported that they averaged 30.0kg at birth.

Among factors which account for differences in birth weight breed as well as sex are known to be important ones.

Gregory, Blunn and Baker (1950) in Hereford calves at North Plette and Valentine sub-stations reported birth weight of males of two groups as 33.6 kg and 34.5 kg, respectively. They observed significant effect of sex and of sire. Koch et al. (1959) in Hereford, Angus and Shorthorn observed that bull calves at birth were 2.4 kg or 1.07 times heavier than females and their average daily weight gain from birth to weaning was 0.05 kg or 1.07 times greater than in females. Witt, Walter and Rappen (1964) also found a significant effect of sex of calf on birth weight. Tantawy (1948) found that average daily gain increased from birth to 29 months. Bull calves increased in weight at greater rate than heifer calves. Asker and Ragab (1953) discussed the various factors affecting birth weight in Egyptian cattle. The values for birth weight for

males and females of these cattle were 25.8 kg and 23.9 kg, respectively. Ahmed and Tantawy (1954) found average birth weights for the same breed to be 27.0 kg for males and 24.0 kg for females. Ghoneim et al. (1959) calculated daily gains of calves of Egyptian breed for three periods : birth to 24 weeks, 24 weeks to one year and 1 year to 2 years. They observed the superiority of males over females from birth upto 18 months. Ragab and Abdel Salam (1962) found no effect of sex on weight at birth but it was significant at 4, 6, 12, 18 and 24 months. Ragab and Abdel-Aziz (1961) reported 32.5 ± 0.4 kg and 30.4 ± 0.4 kg birth weight for male and female Friesians respectively. Sexes differed significantly in birth weight. Kassab and Stegenga (1964) observed birth weight values of 36.9 kg and 32.8 kg in male and female Friesian calves, respectively. Mukhtar (1961) reported birth weight in Darfur cattle to be 24.5 kg and 21.8 kg for males and females respectively. Suchánek (1961) recorded that males were 8.5% heavier than females at birth. Vasileva (1968) studied growth in Isker calves and Sofia Brown calves, and found that birth weight of males was significantly greater than that of females. Differences among sexes in body weights were maintained at all ages.

Seasonal variations have also been reported in birth

weights. According to Ragab and Abdel-Aziz (1961) sexes differed significantly in birth weight. It ranged from 26.6 ± 1.6 kg for August calvings to 32.9 ± 0.6 kg for January calvings. Similarly, Mukhtar (1961) found that calves of both sexes born in July-October (Autumn) were heavier than those born in other seasons. Tyler, Chapman and Dickerson (1947) and Suchánek (1961) could not notice any seasonal effect on birth weight of calves.

Sire is reported to be another factor affecting birth weights. Gregory, Blunn and Baker (1950), Suchanek (1961), Ellis et al. (1965) and Osman and Rizgalla (1968) all noted significant sire effects on birth weight.

Growth rate from birth to various ages has also been studied by many workers. Williard (1948) calculated average daily gain in Holstein calves to be 0.63 ± 0.05 kg from birth to 180 days and 0.72 ± 0.09 kg from 180 days to 365 days, respectively. Muñoz (1964) noted average daily weight gain in crossbreds to be 558 gms from birth to 18 months. Neville (1962) reported in Hereford calves that calves heavier at birth maintained the advantage.

The results of Vsjakih and Borozdina (1960) agreed with those of Neville. They observed that the calves with greater birth weight were also heavier subsequently.

Similarly Valka and Suchánek (1968) in Czechoslovak Red Spotted females found that calves with above average birth weight had higher average body weight at 18 months of age. Auriol et al. (1963) studied the possibility of predicting the growth of an individual calf in Charolais breed from its birth weight. They concluded that birth weight gave a good estimate of adult weight for a group however it could not predict the growth of an individual calf. Similarly Smirnov (1959) in Simmental Lebedian and Red Steppe cattle had found that birth weight was directly related to adult body weight. Body weights at 6 months and 12 months were also related to adult weight.

Little work has been done on Indian breeds in these respects. Lazarus and Rangaswami (1950) studied birth weights in Gir, Hariana, Red Sindhi and Tharparkar breeds. An average birth weight of males of these breeds was 23.7 kg and that of female was 22.0 kg. Birth weight was highest in males for Gir and Tharparkar and in females for Gir and Hariana. Sharma et al. (1951) recorded birth weight of Hariana males to be 24.5 ± 0.2 kg and of females to be 23.8 ± 0.2 kg with overall average to be 24.0 ± 0.2 kg. Singh and Desai (1959) and Kohli et al. (1962) in Hariana noted the values in males to be 24.7 kg and 23.7 ± 0.4 kg and in females to be 22.6 kg and 21.7 ± 0.2 kg, respectively.

Mudgal and Ray (1965, 1966) reported birth weights of male Sahiwal, Tharparkar and Red Sindhi calves to be 21.8 ± 1.8 kg, 21.7 ± 1.9 kg and 21.1 ± 2.2 kg, respectively and for females to be 20.8 ± 2.1 kg, 21.0 ± 2.2 kg and 20.1 ± 2.2 kg, respectively.

Effect of sex on birth weight has been found to be significant. Tôrres (1961) observed males to be 7-12% heavier than females at birth in Gir, Nellore, Kankrej and Indo-Brazilian breeds; sex difference was most marked in Nellore. Mudgal and Ray (1965, 1966) noted significant differences between sexes in Tharparkar and Red Sindhi cattle. Singh and Desai (1959) observed that birth weights of male and female progenies of the same bull differed significantly.

Seasonal variation in birth weights have been studied in some Indian breeds. Chieffi et al. (1950) found that Nellore male calves born in dry season were 3.7 kg lighter than those born in rainy season. Tôrres (1961) reported that birth weights from March to May in Gir, Nellore, Indo-Brazilian and Gujrati breeds were significantly heavier than in other months. Mudgal and Ray (1965, 1966) noted that Tharparkar and Sahiwal calves born in November-February had significantly higher growth rates than of those born at other times.

Singh and Desai (1959) could not find any sire effect on birth weight of Hariana calves. Torres (1961) reported that birth weight and rate of gain was influenced by breed and by year of birth.

The rate of gain from birth upto 90 days and from birth upto 120 days increased most in Kankrej than Indo-Brazilian, Nellore and Gir cattle (Torres, 1961). The lowest rate of gain was observed in Gir. Mudgal and Ray (1965, 1966) calculated average daily gain from birth upto 2½ months in males of Sahiwal and Tharparkar breed and found it to be 309 gms and 347 gms, respectively. In females the corresponding values were 293 gms and 290 gms respectively. The daily rates of gain in these two breeds from 2½ months to 6 months were 476 gms and 505 gms in males and 407 gms and 454 gms in females, respectively.

Inheritance of birth weight had been studied by Gregory et al. (1950) in two herds of Hereford breed reared at two substations. The heritability estimates were 0.45 and 1.00. The other estimates of heritability of birth weights reported are Asker and Ragab (1953) in Egyptian cattle 0.42, Singh and Desai (1959) in Hariana cattle 0.14, Auriol et al. (1963) in Charolais cattle 0.24 ± 0.21 and Alim (1964) in Kenana calves 0.18 ± 0.21. Witt et al. (1964)

estimated the heritability of birth weight in Black Pied cattle from variance component between sires within years and found it to be 0.54.

GROWTH FROM BIRTH UPTO THREE YEARS

Rapid growth during first year of life was noted in Gascony cattle by Pons (1934); the growth was maintained until 40 months after which it was regarded as practically complete. Rasch (1965) discussed methods of measuring growth namely fitting of polynomial and fitting of asymptotic curve. Growth curves have been studied in various breeds of cattle by many workers. Reinhold and Schulze (1934) in Montafon, Murboden-Murztal and Corianthian Blonde cattle studied various body measurements and correlated these with age; on these basis they developed a growth curve formula. By the application of the formula thus evolved they concluded that cattle could be evaluated within a breed as also different breeds could be compared.

Sirbulescu et al. (1958) and Smirnov (1959) have studied relationship between growth and birth weight. Differences in growth rates of Red Sindhi and its crosses with Jersey, Brown Swiss, Holstein-Friesian and Guernsey breeds were analysed by Rathore (1949) and of Red Sindhi-Jersey crosses by Maltos et al. (1962) and they found that

the various groups differed significantly. Nikolic and Simovic (1965) and Gerov and Krastanov (1968) could not notice these differences in Black Pied and Friesians, Brown Alpine and third generation crosses of Isker and Alpine cattle respectively.

Results on a number of factors affecting growth rate and live weight (e.g. birth weight, sex, castration, feeding schedule, season, state of health, lactation, stage of pregnancy, breed and heredity) have been reviewed by Vos (1966). Significant difference was noted between growth of male and female calves by Pons (1934), Jardão and Assis (1939), Fontes (1950), Neville (1962) and Sirbulescu (1962).

Ruby et al. (1948) found larger winter gains in Hereford calves. The regression coefficient of summer gain on winter gain being 0.22. Phillips (1946) reported that in milking Short-horn the average gain during May to October was greater than during winter months. Calves born in autumn (October to December) made much greater gains during their first 700 days (334 kg) than those born during the rest of the year (289 kg).

Maltos et al. (1962) found poorest growth in December to February and most rapid from June to August in Jersey-Sindhi

crosses. Heyns (1959) in Afrikender breed reported that calves born in October to December attained an average weight at six months of age to be 184 kg and an average daily gain of 0.80 kg. Those born after December attained 165 kg at six months of age with only 0.72 kg average daily gain. Höll and Šrámek (1959) observed faster growth in Czechoslovak Red Spotted heifers born from July to October, it was slow in calves born in March and April. The difference between two seasonal groups progressively increased with age becoming significant at 180 days. Suchánek (1961) noted that weight gains in spring born calves were less than in autumn born calves. Mattoso (1961) reported in Indo-Brazilian, Nellore, Gujrati and Gir cattle that season of year influenced weight gains. Sire effects were detectable on growth of German Simmental calves upto 2 years of age by Bachner (1960).

Environmental factors affecting growth rate such as winter feeding, summer grazing, variable farm conditions, have been studied by Kidwell (1954), Martin (1956) and Monsma (1960).

Ridler et al. (1963) found that irrespective of the time of year the rate of gain increased significantly from birth upto 3 or 4 months of age and after which it declined.

Constantinescu (1964) drew up a table by which monthly weight gains could be adjusted to the exact age of calf. Mudgal and Ray (1966) reported the regression coefficients of growth on age in months between 7th month to 12 months to be 7.81 ± 2.95 kg in males and 6.91 ± 2.71 kg in females. Between 1 and 2 years it was 10.45 ± 2.72 kg and 8.69 ± 2.38 kg for males and females respectively.

Inheritance of average daily gain, efficiency of gain in feed lot and days to reach 409 kg in Short-horns were studied by Kohli et al. (1952). The estimates of heritability calculated by paternal half-sib correlation method for these were 63.6%, 25.6% and 3.6%, respectively.

STANDARDS FOR BODY WEIGHTS

Lebedev (1939) discussed the necessity of preparing standards of live weights and of gains at different ages (i.e. at birth and at 3, 6, 12, 18 and 24 months). Jordão and Assis (1939) and Matthew and Fohrman (1954) studied growth curves in Dutch cattle and in Jersey cattle. Vissac and Charlet (1957) studied individual growth curves from birth to six months for Charolais cattle. They established standard curves for male and female calves separately. Häll (1968) by using Brody's growth equation in Red Spotted heifers calculated five different monthly body weight standards upto 30 months of age.

Pons (1934) reported that males in Gascony breed doubled their weights at 1½ months, at 3-4 months, at 9-10 months and at 30 months whereas the females at 1½ months, at 4½ months, at 14 months and at 18 months, respectively. Bowling and Putnam (1943) concluded that Ayrshire cattle increased steadily in body weight until productive maturity was reached. Ott (1940) found that half of the final weight was reached at 14 months and 2/3rd at 2 years in Black Pied Lowland cattle. Torreèle (1965) reported in East Hemish bulls the heritability of weight deviations from mean growth curve to be 0.25 ± 0.3.

MATERIALS AND METHODS

The data on Hariana cattle maintained in Farm Animal Genetics Section, Indian Veterinary Research Institute, Izatnagar, U.P., India, over a period of 19 years i.e. from 1950 to 1968 were utilized for this investigation. The foundation stock of this herd was established in 1937. The herd has been a closed one since 1955.

The calves were weighed first within 18 hours after birth. They were then weighed every eighth day from the date of birth. This continued till 52 weeks. Thereafter the young stock was weighed once a calendar month about 30 days apart upto the age of 5 years. Weighment is done in early hours of the morning before calves have had feed for the day.

An Avery weighing balance was used for weighment upto the age of one year. The capacity of this balance goes upto 250 kg and records the weight upto 0.5 kg correctness. Beyond this age, the calves were weighed on an Avery weigh bridge, capacity of which goes upto 1500 kg. The weighments were recorded in pounds upto 1961 and in kilograms thereafter. All weights were converted into kilogram.

Feeding and Managerial Practices

The feeding schedule of weaned calves upto six months

was as under :

Groups	Milk in gms/10 kg body weight	Separated milk in gms/10 kg body weight
1-3 days	1000	-
4-7 days	1000	-
2nd week	1250	-
3rd week	1250	-
4-6 weeks	750	250
7-9 "	500	400
10-12 "	300	500
13-17 "	100	500
17-19 "	-	400
20-23 "	-	250
24-26 "	-	100

By the end of first month, the calves were given 50 gms concentrate mixture per 10 kg body weight. This continued only for the next two to three weeks and then upto one year the concentrate mixture was given daily at the rate of 85 gms per 10 kg body weight. The concentrate mixture consisted of 20 parts crushed barley, 25 parts wheat bran, 20 parts linseed cake, 10 parts groundnut cake, salt, minerals and trace elements were added to the concentrate mixture at the rate of 1 part per 100 parts of

Statistical Methodology

Data on body weights in pounds were first converted to kgs before statistical analysis. The linear regression coefficients, their standard errors, and tests of significance of difference between two regression coefficients were calculated and tested as per Snedecor (1967). The expected values for body weight were calculated by prediction equation :

$$Y = a + bX$$

Where, Y = body weight of calf,

a = constant,

b = regression coefficient,

X = age of calf.

To test the effects of sire and sex at different ages, method of fitting constants as described by Goulden (1952) was followed. The model used for analysis was :

$$Y_{ijk} = \mu + \alpha_i + \beta_j + E_{ijk}$$

Where, μ = general mean,

α_i = effect of sire,

β_j = effect of sex,

E_{ijk} = error.

Wherever sire x sex interaction was statistically significant, separate analysis for male and female was carried out. Within a sex, sire effects were compared and the sire components were estimated by analysis of variance (one-way classification) technique as described by Snedecor (1967). The model used for analysis was :

$$X_{ij} = \mu + \alpha_i + E_{ij}$$

Where, μ = overall mean,

α_i = effect of sire,

E_{ij} = error.

Estimation of Heritability

The heritability (h^2) was calculated from sire component (σ^2_S) by using paternal half-sib correlation method.

$$h^2 = \frac{4\,\sigma^2_S}{\sigma^2_P}$$

Where σ^2_P is the total phenotypic variance.

The standard error of heritability was calculated from the formula given by Robertson (1959).

$$SE(h^2) = \left[h^2 + \frac{4}{n}\right] \sqrt{\frac{2}{N}}$$

Where h^2 = heritability estimate,

n = average number of progeny per sire,

N = number of sires.

RESULTS

BIRTH WEIGHT

Average weight of male calves at birth was 24.8 kg and of females it was 22.4 kg. Table 1 presents analysis of variance for this character.

Table 1

Analysis of Variance of Birth Weight in kg of Hariana Calves at IVRI, Izatnagar

Source of variation	D.F.	S.Sq.	M.Sq.	F	E.M.Sq.
Between sire	20	541.66	27.08	2.1156**	$\sigma^2_w + K_2\sigma^2_S$
Between sex	1	675.49	675.49	52.7726**	$\sigma^2_w + K_1\sigma^2_X$
Error	524	6708.88	12.80		σ^2_w
Total	545				σ^2_P

K_1 = 269.01; K_2 = 25.43

Sire = 3.54%

Sex = 15.55%

Environment = 80.91%

h^2 = 0.14 ± 0.09

Sex differences were statistically significant as were differences among groups of progenies of different sires. Sire x sex interaction was negligibly small. 15.5% of the total variation was attributable to sex differences and only 3.5% to sire to sire differences, leaving 80.91% due to uncontrolled environmental causes.

Heritability estimate for birth weight by paternal half-sib correlation method for the pooled data was 0.14 ± 0.09.

BODY WEIGHTS AT THREE, SIX, NINE AND TWELVE MONTHS

After birth calves were reared as weaned or unweaned. Growth rate and body weight at these ages were likely to be different among these two groups. Thus the analyses were carried out separately for weaned and unweaned calves.

Table 2 presents the analysis of variance of body weights at 3 months for weaned calves.

Sex difference was not significant at this age but sire differences were statistically highly significant. Average weight of weaned male and of female calves at three months was 46.2 kg and 44.2 kg, respectively.

Table 2

Analysis of Variance of Body Weight in kg at Three Months of Weaned Hariana Calves at IVRI, Izatnagar

Source of variation	D.F.	S.Sq.	M.Sq.	F	E.M.Sq.
Between sire	7	3945.81	563.69	7.64**	$\sigma^2_w + K_2\sigma^2_S$
Between sex	1	218.33	218.33	2.96	$\sigma^2_w + K_1\sigma^2_X$
Error	94	6934.00	73.77		σ^2_w
Total	102				σ^2_P

K_1 = 51.26; K_2 = 12.65

Sire = 33.6%

Sex = 2.4%

Environment = 64.0%

h^2 = 1.34 ± 0.88

Sire and sex interaction was negligibly small. 33.5% of variation was attributable to sire to sire differences, 2.4% to sex differences leaving 64% for the environmental variation.

Heritability of the weight at 3 months by paternal half-sib correlation method was found to be 1.34 ± 0.88.

Table 3 presents the analysis of body weight at 3 months for unweaned calves.

Table 3

Analysis of Variance of Body Weight in kg at Three Months of Unweaned Hariana Calves at IVRI, Izatnagar

Source of variation	D.F.	S.Sq.	M.Sq.	F	E.M.Sq.
Between sires	17	4768.08	280.47	2.88**	$\sigma^2_w + K_2\sigma^2_S$
Between sexes	1	132.05	132.05	1.35	$\sigma^2_w + K_1\sigma^2_X$
Error	356	34712.73	97.51		σ^2_w
Total	374				σ^2_P

K_1 = 184.03; K_2 = 20.32

Sire = 8.4%

Sex = 0.2%

Environment = 91.4%

h^2 = 0.34 ± 0.18

No sex difference was observed although sire to sire differences were significant. Sire x sex interaction was negligible. 8.4% variation was found to be due to sires and 0.2% was due to sex. Thus 91.4% of variation was found to be due to environmental causes.

Heritability of weight at 3 months was estimated by paternal half-sib method to be 0.35 ± 0.18 in unweaned calves.

Analysis of variance of body weight at 6 months for weaned calves is presented in Table 4.

Sex difference was not significant at this age but sire differences were statistically significant. Sire x sex interaction was not significant.

Only 25.3% of the variation was found to be due to sire, 2.3% was due to sex and environmental variation was 72.4%. Heritability estimate as calculated by paternal half-sib method was 1.01 ± 0.68.

Table 4

Analysis of Variance of Body Weight in kg at Six Months of Weaned Hariana Calves at IVRI, Izatnagar

Source of variation	D.F.	S.Sq.	M.Sq.	F	E.M.Sq.
Between sire	7	4828.55	689.79	5.01**	$\sigma^2_w + K_2\sigma^2_S$
Between sex	1	342.70	342.70	2.49	$\sigma^2_w + K_1\sigma^2_X$
Error	84	11560.64	137.63		σ^2_w
Total	92				σ^2_P

K_1 = 46.24; K_2 = 11.50

Sire = 25.3%

Sex = 2.3%

Environment = 72.4%

h^2 = 1.01 ± 0.68

Similarly body weights of unweaned calves at 6 months were analysed. The sire and sex effects are presented in Table 5.

Table 5

Analysis of Variance of Body Weight in kg at Six Months of Unweaned Hariana Calves at IVRI, Izatnagar

Source of variation	D.F.	S.Sq.	M.Sq.	F	E.M.Sq.
Between sire	16	14234.29	889.64	3.03**	$\sigma^2_w + K_2\sigma^2_S$
Between sex	1	664.82	664.82	2.26	$\sigma^2_w + K_1\sigma^2_X$
Error	295	86622.01	293.63		σ^2_w
Total	312				σ^2_P

K_1 = 154.07; K_2 = 18.04

Sire = 10.1%

Sex = 0.7%

Environment = 89.2%

h^2 = 0.40 ± 0.21

The sex difference was not statistically significant. Sire to sire differences were highly significant. Sire x sex interaction was negligibly small. 10.1% variation was due to sires, 0.7% variation due to sex and 89.2% of variation was found to be due to environmental causes.

Heritability of 6 months body weight in unweaned Hariana calves by paternal half-sib method was 0.40 ± 0.21.

Table 6 presents the analysis of body weight of weaned calves at 9 months of age.

Table 6

Analysis of Variance of Body Weight in kg at Nine Months of Weaned Hariana Calves at IVRI, Izatnagar

Source of variation	D.F.	S.Sq.	M.Sq.	F	E.M.Sq.
Between sire	6	13274.92	2212.49	9.94**	$\sigma^2_w + K_2\sigma^2_S$
Between sex	1	987.08	987.08	4.43*	$\sigma^2_w + K_1\sigma^2_X$
Error	63	14028.02	222.67		σ^2_w
Total	70				σ^2_P

K_1 = 35.49; K_2 = 10.04

Sire = 44.8%

Sex = 4.9%

Environment = 50.3%

h^2 = 1.79 ± 1.16

Both sex and sire differences were statistically significant at this age. The sire x sex interaction was negligible. 44.8% variation was found to be due to sire, 4.9% due to sex and environmental variation was to the extent of 50.3%.

Heritability estimate was found to be 1.79 ± 1.16 by paternal half-sib method.

Analysis of body weight of unweaned calves at 9 months of age showed sire and sex differences significant statistically. Interaction (sire x sex) was negligibly small as presented in Table 7.

Only 7.9% of variation was due to sires. Variation due to sex was 2.3% and environmental variation was 89.8%. Heritability of body weight at 9 months of unweaned Hariana calves was 0.32 ± 0.19.

Table 7

Analysis of Variance of Body Weight in kg at Nine Months of Unweaned Hariana Calves at IVRI, Izatnagar

Source of variation	D.F.	S.Sq.	M.Sq.	F	E.M.Sq.
Between sire	16	26063.80	1628.99	2.43**	$\sigma^2_w + K_2\sigma^2_S$
Between sex	1	2936.85	2936.85	4.38*	$\sigma^2_w + K_1\sigma^2_X$
Error	263	176212.99	670.01		σ^2_w
Total	280				σ^2_P

K_1 = 135.87; K_2 = 16.22

Sire = 7.9%

Sex = 2.3%

Environment = 89.8%

h^2 = 0.32 ± 0.19

The analysis of body weights at 12 months in weaned and unweaned calves has been presented in Tables 8 and 9, respectively.

Table 8

Analysis of Variance of Body Weight in kg at 12 Months of Weaned Hariana at IVRI, Izatnagar

Source of variation	D.F.	S.Sq.	M.Sq.	F	E.M.Sq.
Between sire	10	15352.99	1535.30	2.46**	$\sigma^2_w + K_2\sigma^2_S$
Between sex	1	3034.19	3034.19	4.86*	$\sigma^2_w + K_1\sigma^2_X$
Error	119	74271.69	624.13		σ^2_w
Total	130				σ^2_p

K_1 = 55.57; K_2 = 11.63

Sire = 10.5%

Sex = 5.8%

Environment = 83.7%

h^2 = 0.42 ± 0.33

Table 9

Analysis of Variance of Body Weight in kg at 12 Months of Unweaned Hariana calves at IVRI, Izatnagar

Source of variation	D.F.	S.Sq.	M.Sq.	F	E.M.Sq.
Between sire	15	26971.19	1798.08	1.73*	$\sigma^2_w + K_2\sigma^2_S$
Between sex	1	8050.33	8050.33	7.73**	$\sigma^2_w + K_1\sigma^2_X$
Error	183	190562.76	1041.33		σ^2_w
Total	199				σ^2_P

K_1 = 92.16; K_2 = 12.35

Sire = 5.2%

Sex = 6.4%

Environment = 88.4%

h^2 = 0.21 ± 0.18

In weaned calves the sex as well as sire to sire differences were statistically significant. The sex x sire interaction was negligibly small. 10.5% of the variation was attributable to sire and 5.8% variation was due to sex. Environmental causes comprised 83.7% of total variation.

Heritability of 12 months body weight in weaned Hariana calves was 0.42 ± 0.33 as estimated by paternal half-sib method.

In unweaned calves, sex and sire to sire differences were statistically significant. The sire x sex interaction was negligible. Heritability of body weight at 12 months was 0.21 ± 0.18 as estimated by paternal half-sib correlation method.

GROWTH RATE

From birth until one year of age, average weekly body weights of Hariana calves studied, separately for each sex, have been presented in Table 10. A linear regression equation was fitted to body weight in kg of these calves on their age in weeks, from birth until 52nd week. This is also presented in Fig. 1. Utilizing the regression equation thus arrived at, the expected values of body weights corresponding to each week of age were calculated, and from these expected body weights, expected growth rate was computed. In Table 10 have been presented all these values viz. observed weekly average values for each sex, weaned as well as unweaned separately, and simultaneously the expected values from birth till 52 weeks of age for all groups.

Table 10

Observed and Expected Values for Growth in kg of Hariana Weaned and Unweaned Calves as Reared at IVRI, Izatnagar

Age in weeks	WEANED				UNWEANED			
	Female		Male		Female		Male	
	Observed	Expected	Observed	Expected	Observed	Expected	Observed	Expected
0	22.4	25.2	24.8	26.6	22.4	27.7	24.8	28.2
1	21.2	26.4	23.9	27.9	26.0	29.5	28.2	30.2
2	24.3	27.7	26.4	29.3	28.4	31.3	31.0	32.2
3	25.6	28.9	28.1	30.6	30.6	33.2	32.9	34.2
4	26.8	30.1	29.3	32.0	32.6	35.0	35.0	36.2
5	28.9	31.4	31.1	33.3	34.3	36.8	37.0	38.2
6	29.9	32.6	33.0	34.7	36.5	38.7	38.7	40.2
7	31.7	33.9	34.6	36.0	38.7	40.5	41.2	42.2
8	33.7	35.1	36.4	37.4	40.9	42.3	43.2	44.2
9	35.6	36.3	38.3	38.7	43.2	44.1	45.1	46.2
10	37.5	37.6	40.1	40.1	45.4	46.0	46.7	48.2
11	39.6	38.8	41.8	41.4	47.3	47.8	49.3	50.2
12	41.8	40.0	44.0	42.8	49.1	49.6	51.9	52.2
13	44.2	41.3	46.2	44.1	52.1	51.5	53.9	54.2
14	45.8	42.5	47.7	45.5	53.0	53.3	56.1	56.2
15	46.8	43.8	50.2	46.8	55.8	55.1	58.6	58.2
16	47.6	45.0	50.0	48.2	58.2	57.0	61.0	60.2

Table 10 (contd)

Age in weeks	WEANED				UNWEANED			
	Female		Male		Female		Male	
	Observed	Expected	Observed	Expected	Observed	Expected	Observed	Expected
17	48.4	46.2	52.1	49.5	59.9	58.8	63.9	62.3
18	49.9	47.5	53.3	50.9	61.9	60.6	65.2	64.3
19	50.6	48.7	54.0	52.2	63.9	62.5	66.9	66.3
20	52.5	49.9	56.0	53.6	66.2	64.3	70.6	68.3
21	53.9	51.2	57.4	54.9	68.2	66.1	71.5	70.3
22	55.1	52.4	51.5	56.3	69.6	68.0	76.6	72.3
23	56.8	53.7	59.9	57.7	72.3	69.8	75.8	74.3
24	57.4	54.9	62.2	59.0	73.5	71.6	78.4	76.3
25	58.3	56.1	62.6	60.4	76.2	73.5	80.7	78.3
26	61.0	57.4	64.4	61.7	78.7	75.3	83.2	80.3
27	61.1	58.6	66.3	63.1	81.2	77.1	83.0	82.3
28	61.8	59.8	66.7	64.4	82.3	78.9	85.6	84.3
29	64.4	61.1	70.2	65.8	83.7	80.8	88.0	86.3
30	64.9	62.3	71.1	67.1	86.0	82.6	90.0	88.3
31	65.8	63.6	70.4	68.5	88.0	84.4	91.7	90.3
32	65.7	64.8	71.6	69.8	89.1	86.3	93.3	92.3
33	66.9	66.0	71.7	71.2	90.4	88.1	95.8	94.4
34	66.9	67.3	73.1	72.5	92.4	89.9	96.3	96.4
35	67.7	68.5	72.7	73.9	94.0	91.8	98.1	98.4
36	68.7	69.7	73.0	75.2	94.3	93.6	100.4	100.4

Table 10 (contd)

Age in weeks	WEANED				UNWEANED			
	Female		Male		Female		Male	
	Observed	Expected	Observed	Expected	Observed	Expected	Observed	Expected
37	69.3	71.0	74.0	76.6	96.6	95.4	102.7	102.4
38	70.0	72.2	75.1	77.9	99.6	97.3	104.8	104.4
39	70.3	73.5	76.6	79.3	101.4	99.1	106.6	106.4
40	71.6	74.7	78.9	80.6	103.1	100.9	108.6	108.4
41	72.6	75.9	79.1	82.0	103.7	102.8	110.6	110.4
42	74.5	77.2	79.9	83.3	105.3	104.6	113.8	112.4
43	76.2	78.4	80.4	84.7	106.5	106.4	114.7	114.4
44	77.0	79.6	81.6	86.0	107.5	108.3	117.9	116.4
45	77.7	80.9	82.1	87.4	108.3	110.1	119.6	118.4
46	80.2	82.1	89.0	88.7	110.1	111.9	119.8	120.4
47	80.7	83.4	91.0	90.1	111.7	113.7	120.9	122.4
48	82.2	84.6	91.7	91.4	112.3	115.6	123.0	124.4
49	84.5	85.8	91.7	92.8	113.3	117.4	123.1	126.5
50	87.6	87.1	92.3	94.1	113.4	119.2	125.4	128.5
51	88.1	88.3	94.5	95.5	115.9	121.1	128.2	130.5
52	96.4	89.5	106.1	96.8	115.1	122.9	127.5	132.5

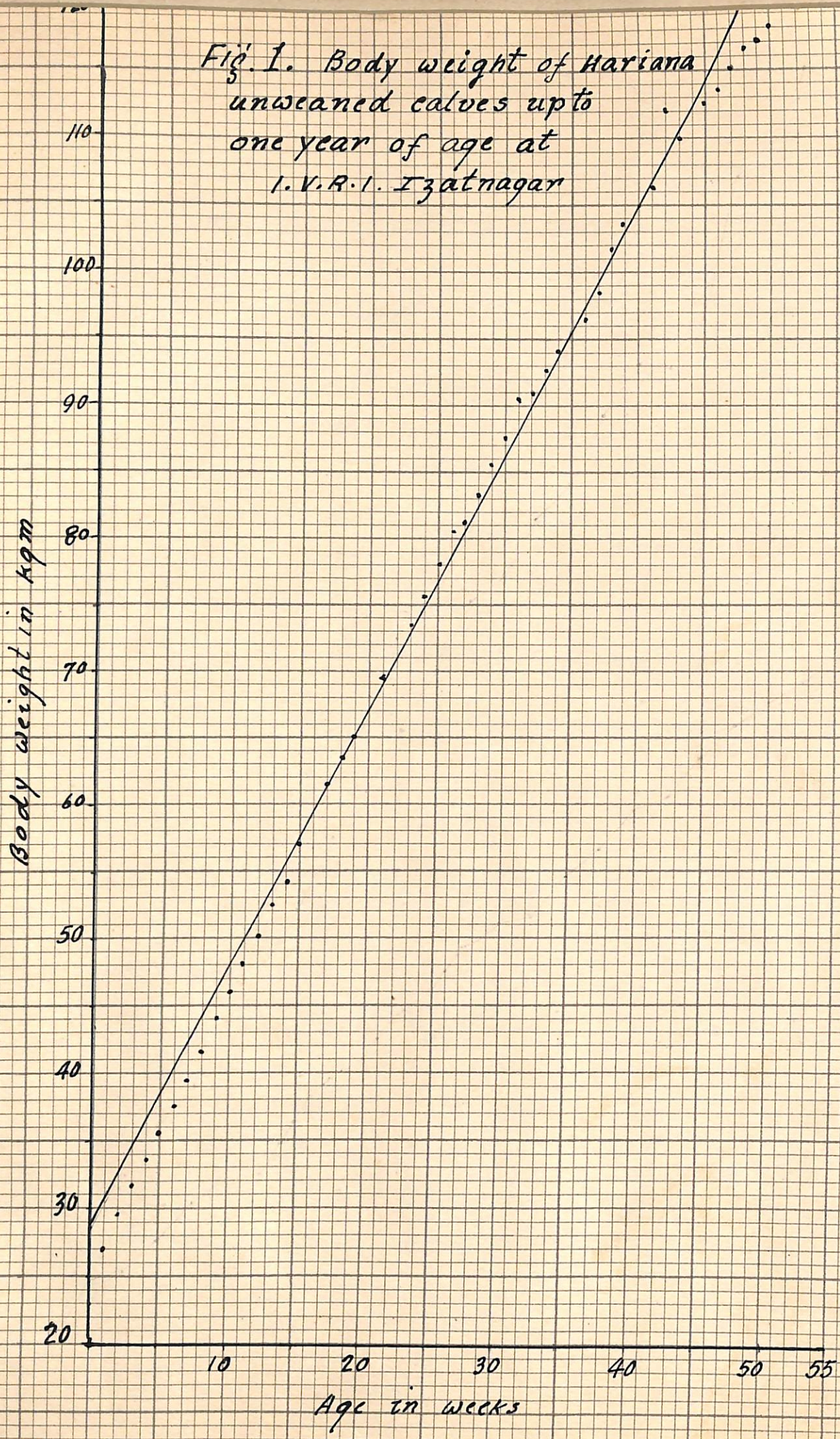


Fig. 1. Body weight of Hariana unweaned calves upto one year of age at I.V.R.I. Izatnagar

Growth rates were also calculated directly sexwise, separately for weaned and for unweaned Hariana calves for the periods listed below :

(i) Birth to three months of age
(ii) Three months to six months of age
(iii) Birth to six months of age
(iv) Six months to nine months of age
(v) Birth to nine months of age
(vi) Nine months to twelve months of age, and
(vii) from birth to twelve months of age.

These sectional growth rates have been presented in Table 11.

Table 11

Average Weekly Gain in Weight in kg at Different Ages from Birth to One Year for Hariana Calves at IVRI, Izatnagar

Period of growth (months)	WEANED CALVES		UNWEANED CALVES	
	Female	Male	Female	Male
0-3	1.74±0.06	1.72±0.04	2.17±0.03	2.14±0.03
3-6	1.24±0.04	1.28±0.15	2.06±0.03	2.23±0.06
0-6	1.54±0.03	1.56±0.05	2.10±0.01	2.21±0.02
6-9	0.73±0.05	0.72±0.07	1.65±0.04	1.87±0.04

Table 11 (contd)

Period of growth (months)	WEANED CALVES		UNWEANED CALVES	
	Female	Male	Female	Male
0-9	1.31±0.03	1.40±0.03	1.20±0.02	2.08±0.02
9-12	1.74±0.15	1.94±0.22	1.09±0.04	1.56±0.08
0-12	1.24±0.02	1.35±0.03	1.83±0.02	2.01±0.02

As calves become older, their growth rate gradually declines. It was nearly 1.75 kg per week in the first 3 months in weaned calves but reduced to less than half during the third 3 monthly period. The rates in unweaned calves were nearly always higher. The reduction in them from the first three months to the last three months of first year of age was much less than in weaned calves. There was no significant difference in growth rate between the two sexes from birth to three months of age. This was true for weaned as well as for unweaned Hariana calves. Similarly, differences in weekly growth rates were statistically non-significant between :

weaned males and weaned females from three months to six months of age;

from birth to six months of age;
from six months to nine months of age
and from nine months to twelve months of age.

On the contrary, the differences were statistically significant between weaned males and weaned females from birth until nine months of age. These differences became highly significant from birth to one year of age. Comparisons among sexes at various ages indicated that unweaned males had significantly higher growth rate than unweaned females from 3-6 months, from birth to six months, six months to nine months of age, birth to nine months of age, from nine months to twelve months of age and from birth to twelve months of age.

Growth rates of weaned and unweaned calves of the same sex were also found to be statistically highly significant at all ages that were studied from birth upto one year of age.

From the analysis of variance of body weights at different ages an attempt was made to estimate effect of sires (which will give a measure of genetic variability in this population) and effect of sex, separately. This was done by calculating the corresponding components of variances. These components expressed as percentage of total variability are comparable for all ages. Therefore, for weaned and unweaned,

separately, these components, expressed as percentage of total variance, are presented in Table 12.

Table 12

Components of Variance for Body Weight in kg Expressed as Percentage of Total Variance for Hariana Calves at IVRI, Izatnagar

Age in months	SEX EFFECT		SIRE EFFECT	
	Weaned	Unweaned	Weaned	Unweaned
3	2.45	0.18	33.58	8.43
6	2.33	0.73	25.26	10.05
9	4.90	2.25	44.80	7.93
12	5.80	6.45	10.50	5.20

Sex effects on body weights of Hariana calves at IVRI, Izatnagar increased as age increased upto one year. Sex effect was much smaller in unweaned calves than in weaned ones. At one year of age these differences between weaned and unweaned calves disappeared.

Sire effects did not follow any clear cut age trend. In general these affected variability greater than did sex differences.

Sire x sex interaction in body weight was not detectable at all ages from birth until one year in both the weaned and unweaned Hariana calves. In weaned group there were 103, 93, 71 and 131 calves at the ages of 3, 6, 9 and 12 months, respectively. The number of sires represented in this group at these ages was 8, 8, 7 and 11, respectively. Similarly in unweaned group there were much larger number of calves, being 375, 313, 281 and 200 resulting from 18, 17, 17 and 16 sires at the same four ages, respectively. Sire to sire differences in body weight of their calves were statistically significant at all ages upto one year of age irrespective of whether the calves were weaned or unweaned.

In weaned group the number of calves per sire was rather small hence the estimate of the sire component of variance in body weight is subject to large sampling variation. As is well known the sire component of variance gives a measure of 1/4 of the genetic variability in the concerned trait. Consequently sire components were multiplied by four to arrive at an estimate of heritability of body weight at different ages for weaned and unweaned calves.

The estimates thus arrived at are presented below :

Age in months	Heritability estimates	
	Weaned	Unweaned
3	1.34 ± 0.88	0.34 ± 0.18
6	1.01 ± 0.68	0.40 ± 0.21
9	1.79 ± 1.16	0.32 ± 0.19
12	0.42 ± 0.33	0.21 ± 0.18

BODY WEIGHT AND GROWTH RATES AFTER ONE YEAR UPTO THREE YEARS OF AGE

Growth studies on body weight were continued beyond one year upto 3 years. No separate study for weaned and unweaned calves was carried out beyond one year. Table 13 presents analysis of body weights of Hariana calves at 18 months of age.

Both sex and sire to sire differences were highly significant. Sire x sex interaction was not significant. Sire effect comprised 9.7% of the total variation, 13.3% variation was due to sexes and 77.0% due to environmental causes. Heritability estimate was 0.39 ± 0.24.

Average body weights of male and female young stock at 18 months of age were 157.6 kg and 134.2 kg, respectively.

Table 13

Analysis of Variance of Body Weight in kg at 18 Months of Hariana Calves at IVRI, Izatnagar

Source of variation	D.F.	S.Sq.	M.Sq.	F	E.M.Sq.
Between sire	16	55263.19	3453.95	3.22**	$\sigma^2_w + K_2\sigma^2_S$
Between sex	1	25135.45	25135.45	23.41**	$\sigma^2_w + K_1\sigma^2_X$
Error	288	309196.94	1073.60		σ^2_w
Total	305				σ^2_P

K_1 = 129.47; K_2 = 17.68

Sire = 9.7%

Sex = 13.3%

Environment = 77.0%

h^2 = 0.39 ± 0.24

Further study on the growth of body weights was done at 2 and 3 years. Table 14 presents the analysis of body weight at 2 years of age.

Table 14

Analysis of Variance of Body Weight in kg at 2 Years of Hariana Calves at IVRI, Izatnagar

Source of variation	D.F.	S.Sq.	M.Sq.	F
Between sire	17	63807.64	6246.61	1.2763
Between sex	1	14014.43	14014.43	2.8634
Sire x sex	17	83204.65	4894.39	
Error	247	361105.34	1461.96	
Total	282			

Both sire and sex differences were not significant. The sire x sex interaction was significant. As sex differences were large, the sire differences might not give the best estimate of heritable differences. Consequently analysis was made separately for male and female calves. The analyses of variance are presented in Tables 15 and 16.

Table 15

Analysis of Variance of Body Weight in kg of Two Years of Male Hariana Calves at IVRI Izatnagar

Source of variation	D.F.	S.Sq.	M.Sq.	F	E.M.Sq.
Between sires	12	55982.59	4665.22	1.7321	$\sigma^2_W + K\sigma^2_S$
Within sires	53	142749.28	2693.38		σ^2_W
Total	65				σ^2_P

K = 4.97

Sire = 12.85%

Environment = 87.15%

h^2 = 0.51 ± 0.51

Table 16

Analysis of Variance of Body Weight in kg of Two Years of Female Hariana Calves at IVRI, Izatnagar

Source of variation	D.F.	S.Sq.	M.Sq.	F	E.M.Sq.
Between sires	17	91029.70	5354.69	4.88**	$\sigma^2_w + K\sigma^2_s$
Within sires	199	218356.06	1097.27		σ^2_w
Total	216				σ^2_p

K = 11.86

Sire = 24.64%

Environment = 75.36%

h^2 = 0.99± 0.43

Sire differences were not observed significantly in males but the difference was highly significant in females. Nearly double the sire component was observed in female than in male (24.64% Vs. 12.85%). The environmental components of variation in males and in females were 75% and 86% respectively. The heritability of body weight at 2 years differed in male and female. The values being 0.51 ± 0.51 and 0.99± 0.43.

Table 17 presents body weight analysis at 3 years.

Table 17

Analysis of Variance of Body Weight in kg of Three Years of Hariana Calves at IVRI, Izatnagar

Source of variation	D.F.	S.Sq.	M.Sq.	F
Between sire	15	78847.86	5256.52	0.8404
Between sex	1	17593.32	17593.32	2.8127
Sire x sex	15	93823.80	6254.92	
Error	204	544398.46	2708.45	
Total	235			

Average monthly body weights, sexwise, were calculated and have been presented in Table 18. These are graphically presented in Fig. 2. It will be seen that linear regression fitted these. Accordingly, from the linear regression equation, expected values for body weights for different ages were calculated. These have also been presented in Table 18.

Table 18

Average Monthly Body Weight in kg of Hariana Male and Female Calves at IVRI, Izatnagar

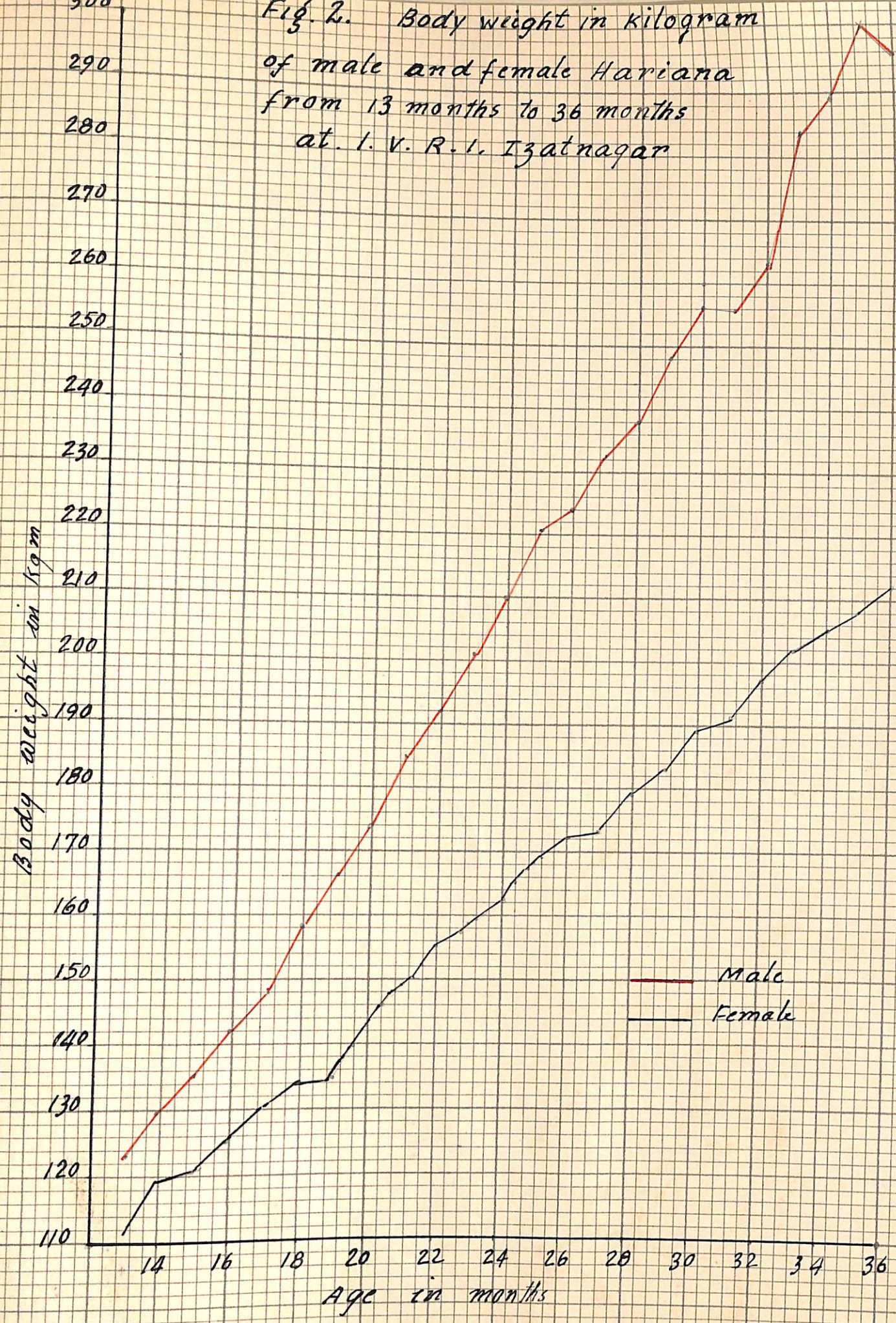
Age in months	Female Calves		Male Calves	
	Observed	Expected	Observed	Expected
13	110.7	112.3	123.5	121.5
14	119.3	116.8	129.6	129.3
15	120.3	121.2	135.2	137.1
16	124.8	125.6	142.0	145.0
17	130.6	130.1	148.0	152.8
18	134.2	134.5	157.6	160.7
19	134.7	139.0	166.5	168.5
20	143.2	143.4	174.3	176.4
21	149.4	147.8	184.4	184.2
22	152.5	152.3	191.9	192.1
23	158.2	156.7	201.1	199.9
24	162.5	161.1	210.2	207.8
25	168.1	165.6	221.1	215.6
26	172.0	170.0	224.5	223.5
27	173.3	174.4	232.5	231.3
28	178.6	178.9	237.9	239.2
29	183.5	183.3	248.3	247.0
30	188.7	187.8	256.1	254.9

Table 18 (contd)

Age in months	Female Calves		Male Calves	
	Observed	Expected	Observed	Expected
31	191.5	192.2	255.8	262.7
32	197.0	196.6	263.0	270.6
33	202.3	201.1	284.6	278.4
34	204.6	205.5	289.4	286.3
35	208.4	209.9	300.4	294.1
36	212.6	214.4	296.3	302.0

The overall average monthly growth rate in males and females was 7.8 and 4.4 kg respectively. Males were slightly under weight as compared to expectation between 15 to 20 months of age.

Fig. 2. Body weight in kilogram of male and female Hariana from 13 months to 36 months at I. V. R. I. Izatnagar



DISCUSSION

BIRTH WEIGHT

Average birth weight of male calves was 24.8 kg and of females it was 22.4 kg. Higher values of birth weights in males have been obtained by Uman (1933) in Red German cattle, Ragsdale (1934), Groenewald (1935), Palicte (1938), Tyler, Chapman and Dickerson (1947), Willard (1948) and Kassab and Stegenga (1964) in Holstein, Brown Swiss, Ayrshire, Guernsey and Jersey, by Venge (1948) in Red and White and in Red Danish, by Vogel (1952) in Spotted Mountain, Spotted Mountain German Red and Black Pied Lowland cattle by Tantawy (1948) in Egyptian cattle, by Rognoni and Pasti (1958) in Friesians, by Suchánek (1961) in Czechoslovak Red Spotted, by Peker and Ozdural (1962) in Koracabey Montafon, by Luna (1964) in Santa Gertrudis, Brahman and Criollo, by Muhamedgaliev et al. (1966) in Ala Tau cattle, by Palicte (1938) in Ayrshire and Nellore Grades and in milking Short horns.

Birth weight values in the present studies are higher than those observed by Mukhtar (1961) in Darfur cattle, by Alim (1964) in Kenana calves in Middle East, by Palicte (1938) in the fourth generation of Ayrshire-Nellore grades, by Muñoz and Rigor (1940) in Red Sindhis, by Lazarus and Rangaswami (1950) in Hariana, Red Sindhi, Tharparkar and Gir,

birth weights significantly. Some workers such as Abelein and Ritter (1959) and Singh and Desai (1959) did not find any sire effect on body weights upto one year of age.

Heritability of birth weight estimated by sire component in the present study was 0.14 ± 0.09. The values observed by Alim (1964), by Auriol et al. (1959), by Gregory (1950), by Asker and Ragab (1953) and by Witt et al. (1964) are more than those observed in the present investigation. In Hariana, Singh and Desai (1959) have obtained more or less a similar value of heritability (0.135) for birth weight. The small difference could be due to herd differences as well as to the number of calves considered for determining this estimate.

BODY WEIGHTS AT THREE, SIX, NINE AND TWELVE MONTHS

Body weights of male and female weaned calves at 3 months were 46.2 kg and 44.2 kg; at 6 months these were 64.4 kg and 61.0 kg; at 9 months these were 76.6 kg and 70.4 kg and at 12 months they were 106.1 kg and 96.4 kg, respectively. The corresponding values for unweaned male and female calves at 3 months were 53.9 kg and 52.1 kg; at 6 months 83.2 kg and 78.7 kg; at 9 months 106.6 kg and 101.4 kg and at 12 months 127.5 kg and 115.1 kg, respectively.

In both the groups (i.e. weaned and unweaned), the

sexes did not differ in body weight upto six months. Ragab and Abdel-Salam (1962) and Vasileva (1966) in their study noted significant sex effects on body weights at 3 and 6 months. The sex differences after 6 months i.e. at 9 and 12 months may be due to change in feeding practices at that stage of the weaned as well as unweaned calves. Unweaned calves get lesser milk because of the declining phase of lactation of cow. Though the calves were fed with concentrates, the change in the milk feeding practices resulted in accentuation of the sex difference at 9 and 12 months. The same reason holds true for weaned calves as well. The milk feeding is stopped at 6 months and calves were fed with greens and concentrates thereafter leading to significant sex difference at 9 and 12 months. The sex difference was found to increase almost from birth upto one year of age in both groups (i.e. weaned and unweaned). At one year differences between weaned and unweaned calves disappeared. No literature on this aspect on Indian breeds is available at present, hence a comparison is not possible.

Sire effects were consistently assessed at 3, 6, 9 and 12 months although they did not follow any clear cut age trend. In general sire effects form the greater part of the genetic variability.

The sire components were found high in weaned calves than in unweaned calves. This could be because of the difference in the expression of genotypes under different managerial practices. Since weaned calves were fed according to their body weight, calves with better genetic make up would show higher body weight and would thus be provided better nutritional levels. While the calves with poor genetic make up would get lower nutritional allowance thereby resulting in greater variability. On the other hand the unweaned calves were allowed to suckle one teat with the result that calves with even poor genetic make up could suckle more milk than scheduled for the calves with better genetic make up. This would result in lessening the variability.

Heritability estimates were higher in weaned calves than in unweaned calves. The sire component expresses 1/4th of the variation of the heritable (genetic) part. Larger component in weaned calves could be due to the added part of gene environment interaction, which blends with the heritable part, resulting into higher estimates of heritability.

GROWTH RATE

The initial differences in rate of gain in weaned and unweaned calves continued upto one year. The rate of gain

decreased in both weaned and unweaned calves from birth upto nine months of age. Similar decline in growth rate from birth to one year was reported in Black Pied cattle by Schmidt and PatowVon (1938). Carneiro and Rhoad (1935) also observed a decline in growth rate after 4 months of age which was further accentuated after weaning of calves. Sectional growth rates (0-3, 3-6, 0-6, 6-9 and 9-12 months) did not differ significantly in weaned calves but the differences which were significant from 0-9 months became highly significant at one year of age. This would indicate that the sectional growth rates do not differ very much but initial differences in growth get accumulated and become marked at one year.

In unweaned calves the growth rate of male was significantly higher as compared with female at all ages upto one year except at 0-3 months. Jordao and Assis (1939) also observed for 6 months higher weekly gains in male Dutch cattle as compared to female. In general the rate of gain from 9 to 12 months was higher than the rate of gain from 0 to 9 months. The growth rate from 0 to 1 year indicated a decreasing trend. The weekly growth rate of male and female weaned calves from birth to one year was 1.35 ± 0.03 kg and 1.24 ± 0.02 kg, respectively and that of unweaned male and

female calves it was 2.01 ± 0.02 and 1.83 ± 0.02 kg, respectively.

BODY WEIGHT AND GROWTH RATES AFTER ONE YEAR UPTO THREE YEARS

Sex and sire effects were significant at 18 months but the effects were not significant at 24 and 36 months. The sire x sex interaction was not significant at 18 months but was significant at 2 and 3 years. Separate analysis for the two sexes at 2 years indicated that the sire influence was evident only in females. This may be due to smaller numbers of males at that age. At three years, sire x sex interaction was highly significant but separate analyses for the two sexes could not be calculated because of very small number of males.

Average monthly growth rate from one to three years for males and females was 7.8 and 4.4 kg. The differences in growth rate of males and females were sustained at these ages also. Though the growth from 1-3 years followed a linear trend - it was observed that from 15-20 months of age the males had a comparatively slower growth rate than would be expected.

SUMMARY

Data on 600 Hariana cattle maintained in the Farm Animal Genetics Section, Indian Veterinary Research Institute, Izatnagar, over a period of 19 years from 1950-1968 were utilised in the present investigation. The data were analysed using standard statistical techniques. Birth weight and body weights at 3, 6, 9, 12, 18, 24 and 36 months were studied. The sire differences were assessed at each of the above mentioned ages. The average birth weight of male calves was 24.8 kg and of female calves it was 22.4 kg. The calves were reared as weaned and unweaned, hence separate analyses were carried out upto one year of age for both these groups. In weaned as well as in unweaned calves the sire differences were significant at 3, 6, 9 and 12 months of age. The sex difference, however, was not significant upto 6 months but was significant at 9 and 12 months of age. The components of variance for sex differences increased from birth to 12 months but the components due to sire did not follow any age trend. The differences between weaned and unweaned calves disappeared at one year of age.

Body weights of male and of female weaned calves at 3 months were 46.2 kg and 44.2 kg; at 6 months these were 64.4 and 61.0 kg; at 9 months these were 76.6 kg and 70.4 kg and at 12 months these were 106.1 kg and 96.4 kg respectively.

The corresponding values for unweaned male and female calves at 3 months were 53.9 kg and 52.1 kg; at 6 months 83.2 kg and 78.7 kg; at 9 months 106.6 kg and 101.4 kg and at 12 months 127.5 kg and 115.8 kg respectively. The heritability estimates for body weights were higher in weaned calves than in unweaned calves at all ages. The growth of calves from birth to one year followed a linear trend, thus expected weight standards have been calculated using a linear regression equation.

The initial differences in rate of gain in weaned and unweaned calves continued upto one year. The rate of gain decreased in both weaned and unweaned calves from birth to 9 months and increased there after upto one year. The weekly growth rates of male and female weaned calves from birth to one year were 1.35 ± 0.03 kg and 1.24 ± 0.02 kg, respectively and those of unweaned male and female calves these were 2.01 ± 0.02 kg and 1.83 ± 0.02 kg respectively.

Growth from one year to three years was also found to be linear. The differences due to sex and sires were significant at 18 months but were not significant at 24 and 36 months. The influence of sire at 2 years of age was evident only in females. Average monthly growth rates from one year to three years for males and females were 7.8 kg and 4.4 kg respectively. The difference in growth rate between males and females was maintained at these ages also.

BIBLIOGRAPHY

Abelein, R. and Ritter, H.C. (1959). Relationships between birth weight and weight at one year in heifer calves in a Spotted Mountain herd in Grub. Mitt. bayer. Landesanst. Tierz. Grub, 7:145-151.

(A.B.A. 28:1857).

Ahmed, I.A. and Tantawy, A.O. (1954). Growth in Egyptian cattle during first two years of age. Alexandria J. agric. Res., 2(1):1-11.

(A.B.A. 23:114).

Alim, K.A. (1964). Factors affecting birth weights of Kenana calves in the Sudan. Emp. J. exp. Agric., 32:307-310.

(A.B.A. 33:1100).

Asker, A.A. and Ragab, M.T. (1953). Causes of variation in birth weight of Egyptian cattle and buffaloes. Indian J. Vet. Sci., 22(1952):265-272.

Auriol, P., Duplan, J.M. and Poirier, P. (1963). Study of the performance of the Charolais breed. C.R. Acad. Agric. Fr., 49:100-107.

(A.B.A. 32:1903).

Bachner, F. (1960). The development of live weight in female German Simmental cattle. Tierzuchter, 12:361-364.

(A.B.A. 29:131).

Baker, A.L. and Quesenberry, J.R. (1944). Comparison of growth of Hereford and F_1 Hereford x Short-horn heifers. J. Anim. Sci., 3:322-325.

Brody, S. (1945). Bioenergetics and Growth. Reinhold Publishing Corporation, New York.

Carneiro, G.G. and Rhoad, A.O. (1935). A study of the growth rate in calves. Bol. Agric. Zootech. Vet. (Minas Geraes), 8(6):327-336.

(A.B.A. 5:15).

Chieffi, A., Andreasi, F. and Veiga, J.S. (1950). A comparison of the growth of Zebu cattle born during the dry and rainy seasons. Rev. Fac. Med. Vet. S. Paulo, 4:315-338.

(A.B.A. 19:1637).

Constantinescu, C. (1964). The exact determination of the body weight of calves at various periods of growth and development. Rev. Zootech. Med. Vet. (Bucuresti), 14(2):89-91.

(A.B.A. 32:2824).

Ellis, G.F. (Jr.), Cartwright, T.C. and Kruse, W.E. (1965). Heterosis for birth weight in Brahman-Hereford crosses. J. Anim. Sci., 24:93-96.

Fontes, L.R. (1950). Differences in the rate of growth and live weight of the Zebu breeds of Brazil. Arq. Esc. Vet. Minas Gerais, 3:47-65 From thesis, Iowa State College, Ames, 1949.

(A.B.A. 19:1584).

Gerov, A. and Krastanov, H. (1968). The growth of crossbreds from Iskur cows and Brown Alpine bulls. Zhivol. Nank., 5(3):45-54.

(A.B.A. 36:3465).

Ghoneim, A., Raafat, M.A., Abouraya, A.K. and Abou-Hussein, E.R.M. (1959). Study of growth in Egyptian cows and buffaloes upto 1½ years old. Bull. Fac. Agric. Cairo Univ., No. 133 (1957) 24 pp.

(A.B.A. 29:2008).

Goulden, C.H. (1952). Methods of statistical analysis. 2nd Edition, John Wiley and Sons Inc., New York.

Gregory, K.E., Blunn, C.T. and Baker, M.L. (1950). A study of some of the factors influencing the birth and weaning weights of beef calves. J. Anim. Sci., 9:338-346.

Groenewald, J.W. (1935). Calf rearing. Fmg. S. Afr., 10: 378-380, 396.

(A.B.A. 3:366)

Hammett (1936).

(c.f. Brody, S. (1945). Bioenergetics and Growth Reinhold Publishing Corporation, New York).

Hammond, J. (1955). Progress in the Physiology of Farm Animals. Vol. 2. Butterworths Scientific Publications, London.

Heyns, H. (1959). Birth weight of beef cattle important. Fmg. S. Afr., 35(8):19-20.

(A.B.A. 28:578).

Heyns, H. (1959). Early summer calves grow rapidly. Fmg. S. Afr., 35(9):28-29.

(A.B.A. 28:580).

Heyns, H. (1965). Birth weights of Afrikaner calves. Proc. S. Afr. Soc. Animal Prod., 1965, 4:154-156.

(A.B.A. 36:1260).

Höll, Č. and Šrámek, J. (1958). The growth and development of bull calves in relation to season of birth. Sborn. Esl. Akad. Zemed. Ved. Zivoc.V'yr., 3(31): 805-822.

(A.B.A. 27:132).

Höll, Č. and Šrámek, J. (1959). Growth and development of heifers in relation to season of birth II. Sborn. Esl. Akad. Zemed. Ved., Zivoc, V'yr., 4(32): 193-212.

(A.B.A. 27:1277).

Höll, Č. (1968). Growth standards for the evaluation of Red Spotted heifers in large herds. Vid. Pr. Vyzk. Ust. Chov. Skotu. Rapotine, 1967, 3:17-30.

(A.B.A. 36:2427).

Jordão, L.P. and Assis, F. de P. (1939). Study on the weight increase in Dutch cattle. Rev. Industr. anim., N.S., 2(4):6-28.

(A.B.A. 9:13).

Kassab, S. and Stegenga, T. (1964). Growth in Friesian calves during the first year of age (52 weeks). J. Anim. Prod. U.A.R., 4:35-43.

(A.B.A. 34:2896).

Kidwell, J.F. (1954). Some growth relations in range cattle. J. Anim. Sci., 13:54-60.

Koch, R.M., Gregory, K.E., Ingalls, J.E. and Arthaud, R.L. (1959). Evaluating the influence of sex on birth weight and pre-weaning gain in beef cattle. J. Anim. Sci., 18:738-744.

Kohli, M.L., Cook, A.C. and Dawson, W.M. (1952). The inheritance of growth rate and efficiency of gain in milking Short-horn steers. J. Hered., 43:249-252.

Kohli, M.L., Suri, K.R., Bhatnagar, V.K. and Kumar, S. (1962). Study of growth in Hariana calves. Indian J. Dairy Sci., 15:52-55.

Lazarus, A.J. and Rangaswamy, M.C. (1950). A study of the birth weight of calves of Indian breeds. Indian J. Dairy Sci., 3:46-51.

Lebedev, I.A. (1939). The planning of growth and development of calves. Socialist Zivotn., No. 5:37-39.

(A.B.A. 9:213-214).

Luna D., J.A. (1964). Comparison of weight gains in bullocks of three pure breeds and their reciprocal crosses.

(A.B.A. 33:2176).

Maltos, J., Roux, H. and De Alba, J. (1962). The problem of the seasonal growth of cattle in a tropical climate. Turrialba, 12:41-42.

(A.B.A. 31:1032).

Martin, T.G. (1956). Factors affecting growth rate of dairy calves. Iowa St. Coll. J. Sci., 30:412-413.

(A.B.A. 25:90).

Matthews, C.A. and Fohrman, M.H. (1954). Beltsville growth standards for Jersey cattle. Tech. Bull. U.S. Dep. Agric. No. 1098:46 pp.

Mattoso, J. (1961). Aspects of the growth of Zebus at Uberaba Experimental Breeding Farm. Experientiae (Vicosa, M. Gerais), 1:65-118.

(A.B.A. 31:1922).

Maynard (1947). Animal Nutrition. 2nd Edition, McGraw Hill, New York.

Montsma, G. (1960). Observations of milk yield, and calf growth and conversion rate, on three types of cattle in Ghana. Trop. Agriculture (Trin.), 37:293-302.

(A.B.A. 29:133).

Mudgal, V.D. and Ray, S.N. (1965). Growth studies on Indian breeds of cattle. I. Studies on the growth of Tharparkar cattle. Indian J. Dairy Sci., 18:14-20.

Mudgal, V.D. and Ray, S.N. (1965). Growth studies on Indian breeds of cattle. II. Studies on the growth of Sahiwal cattle. Indian J. Dairy Sci., 18:65-71.

Mudgal, V.D. and Ray, S.N. (1966). Growth studies on Indian breeds of cattle. III. Studies on the growth of Red Sindhi cattle. Indian J. Dairy Sci., 36:80-89.

Muhamedgaliev, F.M., Ahatov, T., Cernov, G.A. and Alesinskaja, N.A. (1966). Growth and development of young cattle obtained by introductory crossing of the Ala Tau and Jersey breeds. Trudy Inst. eksp. Biol. Alma-Ata., 3:168-174.

(A.B.A. 36:201).

Mukhtar, A.M.S. (1961). Some observations on the rate of gain, birth and weaning weights of Southern Darfur calves in regard to sex, season and the respective size of dams. Sudan J. Vet. Sci. Anim. Husb., 2:208-211.

(A.B.A. 31:162).

Muñoz, C.H. (1964). Growth of half-bred Brahman, Santa Gertrudis and Criollo heifers.

(A.B.A. 33:2178).

Muñoz, M. and Rigor, T.V. (1940). The birth weights of Red Sindhi cattle at Alabang Stock Farm. Philipp. J. Anim. Industr., 7:263-267.

(A.B.A. 9:9-10 pp).

Neville, W.E. Jr. (1962). Influence of dam's milk production and other factors on 120 and 240 day weight of Hereford calves. J. Anim. Sci., 21:315-320.

Nikolic, D. and Simovic, B. (1965). The growth of Black Pied cattle from one day to two years of age. Slocarstvo., 19:133-139.

(A.B.A. 35:1212).

Osman, A.H. and Rizgalla, Y. (1968). Normal growth and development upto one year of age of Sudanese cattle with special reference to the influence of sex and sire. J. agric. Sci., Camb., 70:117-121.

Ott, A. (1940). Development of Black Pied Lowland cattle from birth to five years of age and statistical analysis of variation in a population of such cattle from birth to three years of age. Z. Tierz. Zucht. Biol., 45:259-308.

(A.B.A. 10:15).

Palicte, L.J. (1938). Rearing dairy calves and their rate of growth under Alabang conditions. Philipp. J. Anim. Industr., 5:293-308.

(A.B.A. 6:289).

Peker, M. and Özdural, O. (1962). Investigations on body development and food conversion in Karacabey-Montafon calves. Lalahan Zootek. Arast. Enst. Derg., 1(12): 30-62.

(A.B.A. 31:1034).

Phillips, R. (1946). Seasonal variation in the rate of growth of young cattle. Nature, 158:202-203.

Muñoz, C.H. (1964). Growth of half-bred Brahman, Santa Gertrudis and Criollo heifers.

(A.B.A. 33:2178).

Muñoz, M. and Rigor, T.V. (1940). The birth weights of Red Sindhi cattle at Alabang Stock Farm. Philipp. J. Anim. Industr., 7:263-267.

(A.B.A. 9:9-10 pp).

Neville, W.E. Jr. (1962). Influence of dam's milk production and other factors on 120 and 240 day weight of Hereford calves. J. Anim. Sci., 21:315-320.

Nikolic, D. and Simovic, B. (1965). The growth of Black Pied cattle from one day to two years of age. Slocarstvo., 19:133-139.

(A.B.A. 35:1212).

Osman, A.H. and Rizgalla, Y. (1968). Normal growth and development upto one year of age of Sudanese cattle with special reference to the influence of sex and sire. J. agric. Sci., Camb., 70:117-121.

Ott, A. (1940). Development of Black Pied Lowland cattle from birth to five years of age and statistical analysis of variation in a population of such cattle from birth to three years of age. Z. Tierz. Zucht. Biol., 45:259-308.

(A.B.A. 10:15).

Palicte, L.J. (1938). Rearing dairy calves and their rate of growth under Alabang conditions. Philipp. J. Anim. Industr., 5:293-308.

(A.B.A. 6:289).

Peker, M. and Özdural, O. (1962). Investigations on body development and food conversion in Karacabey-Montafon calves. Lalahan Zootek. Arast. Enst. Derg., 1(12): 30-62.

(A.B.A. 31:1034).

Phillips, R. (1946). Seasonal variation in the rate of growth of young cattle. Nature, 158:202-203.

Pons, P. (1934). Growth in stature and weight in Gascony cattle with black mucosa. Rev. Vet. (Toulouse), 86:601-620.

(A.B.A. 5:14).

Ragab, M.T. and Abdel-Aziz, A.S. (1961). The effect of some environmental factors on body weight and relative growth rate in Friesian calves of Tahreer Province. J. Anim. Prod. U.A.R., 1:107-120.

(A.B.A. 31:2794).

Ragab, M.T. and Abdel-Salam, M.F. (1962). The effect of sex and month of calving on body weight and growth rate of Egyptian cattle and buffaloes. J. Anim. Prod. U.A.R., 2:109-132.

(A.B.A. 33:3270).

Ragab, M.T. and Abdel-Salam, M.F. (1963). Relation and inter-relation between body weights and growth rates of cattle and buffaloes at some different ages of life. J. Anim. Prod. U.A.R., 3:27-43.

(A.B.A. 33:3271).

Ragsdale, A.C. (1934). Growth standards for dairy cattle. Missouri Agric. Exp. Sta. Bull. No. 336:12 pp.

(A.B.A. 2:204 pp).

Rasch, D. (1965). Biometric methods for the measurement of growth. Arch. Tierz., 8:397-404.

(A.B.A. 34:1957).

Rathore, A. (1949). Differences in the growth of Sindhi and crosses of Sindhi with Jersey, Brown Swiss, Holstein-Friesian and Guernsey cattle. Iowa St. Coll. J. Sci., 1951, 25:345-347.

(A.B.A. 20:1550).

Reinhold, F. and Schulze, R. (1934). Nature and Method of Evaluation of Growth Curves illustrated by the Course of Development in Three Alpine Cattle Breeds. Landw. Jahrb., 80:459-495.

(A.B.A. 2:314-315 pp).

Ridler, B., Broster, W.H. and Foot, A.S. (1963). The growth rate of heifers in a dairy herd. J. agric. Sci., 61:1-8.

Robertson, A. (1959). Populations genetikund quantitative vererbung. Handbook des Tierzuchtung Bd., 2:77.

(c.f. Nagarcenkar, R. (1963). Prod. Anim. (1964) 3:127).

Rognoni, G. and Pasti, C. (1958). The correlation between birth weight and average live weight increase during the first six months in Friesian and Brown Alpine calves. Atti. Soc. ital. Sci. vet., 1957, 11 (Suppl. to Arch. Vet. ital.9 No. 2):338-339.

(A.B.A. 26:1856).

Ruby, E.S., Blunn, C.T., Brouse, E.M. and Baker, M.L. (1948). Relation of initial weights and subsequent gains of weanling calves. J. Anim. Sci., 7:279-282.

Schloss, E. (1911). Pathologie des wachstums, P.I. Berlins, S. Korgen (Quoted by Maynard, L.A. (1947) Animal Nutrition, 2nd Edition, McGraw Hill, New York).

Schmidt, J. and Patow, C. Von (1938). Studies on the development of the ♀ progeny of the herd of Black Pied cattle at the experimental and research farm, Koppehof, University of Berlin. Z. Tierz., 41:5-27.

(A.B.A. 7:111-112 pp.)

Sharma, G.P., Vali, K.N. and Suri, K.R. (1951). Studies on the Hariana breed of cattle. Res. Bull. E. Panjab Univ. Zool. No. 18:57-68.

Singh, S.B. and Desai, R.N. (1959). Inheritance of birth weight in Hariana cattle. I. Indian J. Dairy Sci., 12:51-55.

Sîrbulescu, V., Coman, C., Mocanu, M., Ghibu, I. and Roman, S. (1958). The dynamics of growth of calves at various ages in relation to birth weight. Probl. Zooteh. Vet. (Bucuresti), 1958(5):32-35.

(A.B.A. 28:1244).

Sîrbulescu, V., et al. (1962). The dynamics of body weight increases in Spotted, Red and Brown cattle to one year of age in relation to sex, birth weight and calving season. Lucr. Sti. Inst. Agron. 'N. Balcescu' (Bucuresti), C, 6:95-106.

(A.B.A. 32:2831).

Smirnov, A. (1959). The importance of the body weight of calves in rearing dairy cows. Mol. Mjasn. Zivotn., 4(10):45-48.

(A.B.A. 28:123).

Snedecor, G.W. and Cochran, W.G. (1967). Statistical Methods. 6th Edition. Oxford and I.B.H. Publishing Co.

Suchánek, B. (1960). Weight gains in cattle. I. The growth of heifers. Sborn. Csl. Akad. Zemed. Ved. Zivoc., Vyr., 5(33):785-802.

(A.B.A. 29:135).

Suchánek, B. (1961). Weight gains in cattle. II. The growth of bull calves. III. Factors affecting growth. Zivocisna Vyroba, 6(34):195-208.

(A.B.A. 30:148).

Suchánek, B. (1961). Birth weight of calves and some causes for its variability. Ved. Prace Vyzkum. Ust. Chov. Skotu. Csazu Rapotine, 1:27-41.

(A.B.A. 30:912).

Tantawy, A.O. (1948). Growth in Egyptian cattle. M.Sc. Thesis, Fac. Agric. Farouk Ist Univ., Alexandria. 68 pp.

(A.B.A. 17:68).

Torreele, G. (1965). Age and weight of East Hemish bulls. Revue Agric., Brux., 18:1039-1053.

(A.B.A. 35:3445).

Tôrres, J.R. (1961). Factors affecting the variation in weight of Zebu suckling calves. II. Month, sex and age of cows. Experientiae (vicosa, M. Gerais), 1:355-443.

(A.B.A. 31:1925).

Tôrres, J.R. (1961). Factors affecting the variation in weight of Zebu suckling calves. I. Breed and year. Experientiae (Vicosa, M. Gerais), 1:281-354.

(A.B.A. 32:937).

Tyler, W.J., Chapman, A.B. and Dickerson, G.E. (1947). Sources of variation in birth weight of Holstein-Friesian calves. J. Dairy Sci., 30:483-498.

Uman, Y.U. (1933). Birth weight as a factor in selection of cattle. Probl. Zhivotn., No. 5:44-49.

(A.B.A. 1:245 pp.).

Valka, K. and Suchanek, B. (1968). The relation between the body weight of heifers at 18 months of age and first lactation yield. Ved. Pr. Uyzk. Ust. Chou. Skotu. Rapotine, 1967:31-36.

(A.B.A. 36:2414).

Vasileva, Ĭ. (1963). The gestation period and birth weight of calves as indices of their growth and development. Nauchni. Trud. Vissh. Salskostop. Inst. Geogri. Dimitrov. Zootekh. Fak., 13:291-317.

(A.B.A. 34:1100).

Vasileva, Ĭ. (1966). The effect of the sex of the calf on gestation period and growth to six months of age. Nauchni. Trud. Vissh. Salskostop. Inst. Geogri. Dimitrov. Zootekh. Fak., 16:247-254.

(A.B.A. 35:3547).

Venge, O. (1948). Influence of different factors on birth weight of calves. Nord. Jordbrforskh., 1948(7/8): 208-224.

(A.B.A. 17:864).

Vissac, B. and Charlet, P. (1957). An example of a method of progeny testing sires for growth rate. Reprinted from Bull. tech. Ing. Serv. agric. No. 125 (4 pp.).

(A.B.A. 26:1858).

Vogel, H. (1952). Body development and food utilisation of Spotted Mountain heifer calves in the first year of life. Zuchtungs kunde, 24:10-21.

(A.B.A. 21:147).

Vos, M.P.M. (1966). Growth in cattle. Veeteelt-enzuivelber, 9:340-350.

(A.B.A. 35:1217).

Vsjakih, A.S., Borozdina, A.P. (1960). Growth and development of young cattle under conditions in the mountains. Trud. Inst. Morf. Zivotn. Severcova, No. 31:100-109.

(A.B.A. 29:1349).

Willard, H.S. (1948). Effect of Holstein birth weight on calf gain and final weight. Bull. Wyo. agric. Exp. Sta. No. 286:14 pp.

(A.B.A. 17:865).

Witt, M., Walter, E. and Rappen, W.H. (1964). Investigation on the effect of various factors on birth weight and the relationship between birth weight and weight at 6 and 12 months in Black Pied cattle. Z. Tierz. Zucht. Biol., 80:3-24.

(A.B.A. 32:2833).