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STUDIES ON GROWTH RATE AND CHEMICAL COMPOSITION OF BLOOD OF THARPARKAR CALVES ON TWO LEVELS OF PROTEIN FEEDING:

THESIS

Submitted to the University of Magadh in partial fulfilment of the requirements for the degree of MASTER OF SCIENCE in Animal Husbandry in the faculty of Veterinary Science:

By

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I certify that this Thesis has been prepared under my supervision by Sri G.N.Sharma, a candidate for the degree of M.Sc. (A.H.) with Animal Nutrition as major subject, and that it incorporates the results of his independent study.

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C O N T E N T S

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CHAPTER-1

INTRODUCTION

" Throughout the animate kingdom, from the simplest microorganisms to the most complexly organized beings, that inexhaustible power of growth which ever since the genesis of the first protoplasm in the infinite past has created the structure of the fossil remains of former ages as well as our own existence - this capacity to grow, has remained as the most remarkable phenomenon of nature, the supreme riddle of life"_____Rubner(1917).

Growth is the foundation of all the important forms of livestock production. Animals of any species will not make any economical gain in any type of production unless they have been properly nourished during their actual growing period. It is true that the maximum productive ability of an individual is largely controlled by its inherited potentialities, but these potentialities can not be reached unless the individual has been provided proper environments since its early stages of life. Good and abundant supply of food constitutes one of the most important parts of such environments.

The economy of early growth is a matter of serious consideration specially for India, which is solely an agricultural country and where the livestock constitute the backbone of its economy. According to Joshi et al (1953) and quoted by Ahmad(1961), India before partition had 28 well defined breeds of cattle, and according to Sen(1953), the total animal population, then, included 215 millions of cattle and Buffaloes, about 97 millions of sheep and goats, 4.5 millions of equines and one million of camels. The overall human population was 380 millions, of which more than 75% depended on the agriculture and thus on animal Husbandry. But the fact remains that most of our even better animals are

usually stunted in size, low yielders and poorer than average in many other important charesteristics. This is mainly due to under- or malnutrition and ill management which have forced them to become an economic burden to the society.

During the last 25 years, the human population has been consistently increasing and according to Mukherjee(1938), the pressure of bovine population varies directly with the human population pressure. While the shortage of human food stuffs can be met by importation from other countries, the same can not hold good in case of animal population where the position of food supply is rather different. A number of workers have drawn attention to this seriousness of the problem and have suggested various ways and means for the proper development of our livestock.

One of the main problems confronting us in the development of our livestock is their retarded or poor growth which is solely due to malnutrition. Unless we achieve success in the acceleration of the growth rates of our livestock economically, our all attempts towards the desired goal are apt to be futile. Unfortunately, much less is known about the problems relating to growth. It is only recently that physiological studies have furnished a good deal of valuable information regarding the major processes of growth. As a result of these studies, now, we are in a position to define the complex phenomenon of growth, measure it, follow its course, and it is still more recently that various methods have been known for the acceleration of its rate.

The economic importance of early growth can well be understood by the facts that the growth rate has a definite influence on feed economy, final product and lengthening of life span(Maynard,1956). The data from the experiments carried out at the Missouri Agricultural Experiment Station by Moulton et al (1922) clearly reveal that "higher planes of nutrition proved more efficient from the standpoint of energy recovery & the production of edible meat. Analysis of a large body of data by Watson (1943) brings out clearly the increased physiological efficiency from higher planes of nutrition. Work of McMeekan (1940-1941) reveals that the growth rate of the different parts as effected by the planes of nutrition influences in turn the composition of the carcass at market weight.

One of the most important features of the effect of planes of nutrition on the growth rate emerges from the extensive series of experiments carried out by Sherman with rats. These experiments show that diets which produced a more rapid rate of growth also resulted in a longer life. On the other hand,McCay's studies clearly reveal that rats whose growth is severely retarded in early life, by calorie restriction only, have a longer life span than those which grow rapidly under ad libitum feeding. Although,these findings of McCay are contrary to those of Sherman, but McCay has also reported that, with animals which had grown normally and continued to receive an ad libitum diet until middle age,calorie restriction thereafter resulted in a longer life. All these findings are of great practical significance in case of breeding and producing animals, where the life time performance is the final measure of the

successes achieved in rearing these animals.

Although, India has had a large cattle population (about ⅓rd of the world's cattle population - Sen and Krishnan, 1941), reliable data on the growth rate for most of our livestock are not available. As quoted by Sen(1953), the only published data available relates to the Sahiwal breed, which have been furnished by Sayer (1934). These data show that the average daily gain of Sahiwal heifers on the ordinary farm diet was 1.03 lb., whereas of those on the special diet (made up of an extra amount of milk and some change in the concentrate) was 1.21 lb. Viswanath (1941) has shown that "heifer calves could be brought to maturity within the age of 19 months", which is considerably less than the usual age of 2½ years. The latest worker, yamdagni, (1962) under the guidance of Dr. S.K.Talapatra at Mathura (India) has shown that growth rate as high as 1.9 lb. daily per head could be obtained in Hariana calves under special feeding regime. It appears, therefore, that under a good system of feeding and management, the growth rate of our livestock can be very closely comparable to that of a similar type of animal reared in the western countries (Sen, 1953). It may be mentioned here that Morrison (1937) has recorded the average daily gain of Jersey heifers to be 1.12 lbs. during the first year.

Since the growth involves an increase in the structural tissues, such as muscles, bones and other internal organs, it is primarily an increase in the protein, minerals and water. From the standpoint of nutrition, it

involves an intake of large amount of energy producing nutrients,minerals(chiefly clacium and phosphorus),and various vitamins. Thus the nutritive requirements for growth are quite different from the requirements for other body functions.

Of all the requirements for growth,the major is that of protein,because, it has been established that about 25% of the increase in weight in young animals is protein and this rate of increase falls down somewhat as the animal matures. Unfortunately,the protein requirement for growth appears to be the least well defined. Only a little experimental information is available concerning the protein requirement of young stocks. Whatever little information is available,the results of the different workers seem to be markedly divergent. These differences are partly because the various scientists have used different biological values and different maintainance requirements for "normal growth".

The feeding standard generally followed in major part of the world is that of Morrison. This standard is based on the study of various investigations carried out in western countries involving feeding trials, balance studies and slaughter experiments where necessary. Recently,factorial method(Mitchell,1948) has also been taken into consideration. A large number of Indian workers namely,Sen(1953) and Lander(1945) have conducted several nutritional and balance studies with Indian livestock and have setforth their recommendations for various physiological functions under Indian conditions. More recently,the N.R.C. of the U.S.A.(1956) has brought out another standard for different classes of livestock which has now received

considerable attention. It is believed that since this recommendation represents the pooled judgement of a group of experts in the field of animal nutrition, it serves as the most practical guide to the need of nutritional requirements of the farm animals, at least for practice in the U.S.A. In fact, the N.R.C. reports comprise feeding standards for the requirements of total food and for all other nutrients for which quantitative data are available.

The investigations on the requirements of various classes of livestock carried out in India, though limited, suggest that the adoption of foreign standards always leaves a fair margin of safety so far as the feeding of Indian cattle is concerned. This is because the mature weights of most of the Indian breeds of cattle are about three - quarter or half as much as those of foreign breeds. Thus, the nutritive requirements of Indian cattle have been found to be about 20% less than those recommended in Morrison and other foreign standards. Although, the details of the various requirements for growth have been discussed in the chapter of review of literatures pertaining to the systems of calf rearing, the recommendations for protein and energy as given by Morrison(1959), the N.R.C. of the U.S.A. (1956), and Sen (1952) may be given here for the purpose of a general review of the situation.

Table I(a) Morrison Feeding Standard for growth:-

Body wt. lbs.	D.M. lbs.	D.C.P. lbs.	T.D.N. lbs.
100	1.8 - 2.4	0.35 - 0.45	1.8 - 2.2
200	4.9 - 6.1	0.55 - 0.65	3.6 - 4.4

Body wt. lbs.	D.M. lbs.	D.C.P. lbs.	T.D.N. lbs.
400	9.1 - 11.4	0.76 - 0.87	6.0 - 7.0
600	12.6 - 15.1	0.83 - 0.94	7.7 - 9.3
800	15.9 - 19.1	0.88 - 0.99	9.1 - 10.9
1000	18.6 - 22.3	0.93 - 1.03	10.0 - 12.0

Table I(b) N.R.C. standard for growing dairy heifers:

Body wt. lbs.	Daily total feed lbs.	D.C.P. %	T.D.N. %
100	2	20.0	100
200	6	10.0	67
400	11	7.3	59
600	15	5.7	57
800	19	4.7	53
1000	22	4.3	50

Table I (c) Indian Standard For Growing Cattle (Sen,1953):

Live wt. lb.	Class I Cattle Mature wt.1000lb		Class II Cattle Mature wt.750 lb.		Class III Cattle Mature wt.500 lb.	
	D.C.P. lb.	T.D.N. lb.	D.C.P. lb.	T.D.N. lb.	D.C.P. lb.	T.D.N. lb.
100	0.32	1.6	0.24	1.2	0.16	0.8
200	0.57	3.7	0.43	2.8	0.28	1.9
400	0.85	6.4	0.64	4.8	0.43	3.2
600	1.0	8.2	0.75	6.1		
800	1.13	9.9	0.85	7.4		
1000	1.25	11.5				

While sufficient information regarding the nutritive requirements of growing calves and the effects of planes of

nutrition on the growth rate are now available, only a little experimental evidence is available to show the effect of plane of nutrition on the level of blood components. From the standpoint of nutrition, the composition of the blood is of great significance in the sense that it is the medium by which the absorbed nutrients are carried to the different parts of the body and by which the waste products of metabolisms are removed. Although, much work has been done on the study of blood chemistry in foreign countries involving different species and under different physiological conditions, the issue has received attention in India only recently. The problems of calf nutrition have now focussed attention on the level of various blood components since these (the latter) often serve as a valuable guide in evaluating the nutritional adequacy of the diet as well as the nutritional state of the animal in question. For example, it has been seen that larger the amount of adipose tissue, the lower is the percentage of blood for the body as a whole. It has been shown in hibernating woodchuck that the figure for blood percentage increases as it uses of its fat reserve (Maynard,1956).

It has been generally said that malnutrition often influences the percentage composition of some of the blood components and also that these are greatly affected by age, sex, breed and season. Among the Indian workers who have taken great pains in their studies in this line, the names of Sen & Roy (1933), Kehar, Singh & Rao (1940), Mullick & Pal (1943) and Kehar & Murthy (1945) are worth mentioning. These workers have

furnished a large body of valuable informations with regard to this aspect of animal nutrition in case of different species of livestock such as, Dhani and Hariana cattle, Murrah buffaloes, Horses, Sheep etc. They have also been able to fix up normal blood values for these species of animals.

The present work is an endevour to study the effects of two different levels of protein and equal amount of energy on the growth rate and blood composition in Tharparker calves. Tharparker breed is a well defined dual purpose breed and has been largely used in Bihar state for various cattle development programmes both in rural as well as in urban areas. A Tharparker herd is being maintained at the Government Cattle Farm, Patna for over 30 years and the Farm is attached to the Bihar Veterinary College for teaching and experimental purposes. Thus, this breed could easily made available the required number of calves for this study.

12 calves were selected on the basis of similarity in age and divided into 2 groups on the body weight basis. One group was fed a concentrate mixture used at the Farm which furnished the average of Morrison's maximum and minimum standard recommendations for growth as regards protein and energy and the other group received a concentrate mixture so constituted that it supplied 25 percent less D.C.P. and the same amount of T.D.N. per lb. as the previous concentrate mixture. Hay and green para grass were fed to both the groups ad lib and daily consumption recorded for each group throughout the experimental period.

The experiment was spread over for about 5 months including a ten days digestion trial during which weekly record of growth rate and fortnightly variation in blood components were studied. The components of blood under study were:-

(a) Serum calcium

(b) Serum Inorganic Phosphorus

(c) Serum total protein

(d) Blood glucose

(e) Haemoglobin

(f) Non-protein nitrogen.

The details of these studies have been discussed in the chapter "Material & Methods".

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CHAPTER II

REVIEW OF LITERATURES

Growth is a highly complex universal phenomenon and is a subject to individual variability i.e. there is a charesteristic rate of growth for each species. In short, it may be said that for all, the rate of the growth is not a constant feature, nor does its entire course follow any simple mathematical expression. Although, the maximum development of an individual is governed by the heredity, but modern scientific techniques have provided measures by which this inherited potentiality can be reached in shorter period of time and these measures are rested on a tripod,viz, Breeding,feeding and management.

Like growth, blood picture is also a highly variable charesteristic. It varies between individual to individual, between species to species and between breed to breed. Even in the same individual it is largely affected by age,sex,season and diet. Therefore, it is misleading to think of an average value as applying to every healthy individual except in certain constituents with a narrow margin,i.e. calcium. There are others, for example, sugar and Nitrogen which rise shortly after a meal and gradually fall to a fasting level.

Inspite of more and more attention having been devoted to the studies of problems relating to growth and the chemistry of blood, we are still unable to claim a complete knowledge of these phenomena. Considerable amounts of work have been done with different breeds in India and abroad on these aspects, but very little data are available for Tharparker cattle. Hence this study is a little venture in these directions.

The literatures cited here in this chapter have been restricted only to those which have been directed towards the study of the features considered in the present work. Besides these, the literatures pertaining to the various nutritive requirements and systems of rearing of dairy calves have also been considered. Consequently, the literatures have been reviewed mainly under the following topics:-

(i) Rearing of dairy calves,

(ii) Growth rate and feed economy,

(iii) Changes in blood components in relation to level of diet.

(i) REARING OF DAIRY CALVES:

Dairy calves are the back bone of dairy industry in every country. Therefore, much emphasis has been laid on proper raising of dairy calves, no matter whether they are to be reared for milk, meat or any other type of economic consideration.

Nutritive Requirements Of Growing Calves:- Before discussing the various methods and general principles of calf rearing, it is necessary to deal with the various nutritive requirements for growth. It has already been mentioned that the rate and character of the body increase vary with age as well as with species. It is evident, therefore, that a feeding standard for growth must be different for each species and must be inclusive of values corresponding to different ages and body weights representing the growth period. For example, a calf, at birth is not actually a ruminant, because the rumen develops a little later. Therefore, it needs high quality and abundance of protein and vitamins including B-complex during its pre-ruminant stage. Its needs for these nutrients at this stage are more or less

similar to those of pigs or chicks. By the time, the rumen has developed and the calf has become a real ruminant, ample B-complex vitamins are synthesized in the fermentations that take place in the rumen and also the quality of protein becomes of much less importance.

Since the body increase represents ~~xhx~~ an increase in the protein, minerals & water & is a subject to fluctuation with age, dairy calves usually require (1) plenty of good quality protein, (2) sufficient energy producing nutrients, (3) enough of minerals concerned in growth and (4) liberal amount of vitamins. Numerous workers have conducted several experiments to fix up normal levels of these requirements as a result of which feeding standards for different classes of livestock have been setforth to serve as a practical guide in proper raising of dairy calves.

(1) Protein & energy Requiremwnts for Growth:- The requirements of these nutrients at different ages and for various body weights have been discussed earlier (p.6-7). It may be mentioned here that the requirement of a given nutrient for growth must include the amount needed for maintenance and also the amount required for the new tissue formed. The values given in the preceeding chapter represent these combined requirements.

(2) Mineral Requirements For Growth:- By far, the principal minerals required for growth are calcium, phosphorus, magnesium & a few trace elements. Of these, the previous three are the important constituents of bones, teeth, cartilages and

other soft tissues. In general,over 70% of the ash of the body consists of calcium and phosphorus, and of these,nearly 99% of calcium and 80% of phosphorus are present in the bones. and teeth. Of the total magnesium of the body,70% is present in the bones and remainders in various body fluids and soft tissues. These three minerals are better discussed together because they are closely related to each other as regards their occurance in a definite ratio, distribution and metabolic functions. The relative importance of these differs considerably in different species and according to physiological functions. In the present discussion, only the requirements of these for growing calves have been dealtwith.

Huffman and associates (1933) as a result of extensive series of experiments with calves have reported that an intake of 6 to 12 g of calcium daily from birth to 2 years of age is sufficient for the growth of calves. As regards phosphorus, they have reported that intakes of 5.7 to 9.9 g per day were inadequate where the Ca: P ratio was 4:1 or wider. An intake of 10.3 g daily sufficed from 3 to 6 months of age, and from 18 months to first calving 10 to 12 g daily were found to be adequate.

Morrison (1936) and Mitchell (1937) have also estimated the calcium and phosphorus requirements for growing cattle. The results obtained by Mitchell were later on reproduced with certain modifications, in which the percentage retention data given by Ellenberger et al (1950) and true absorption coefficients for these minerals have also been taken into consideration.

The requirements of calcium and phosphorus recommended by these workers are well illustrated in table II. It may be mentioned here that the recommendation given by Morrison represents the daily requirement of a growing calf and so does the recommendation given by Mitchell, but in the latter case, the values are represented in terms of gross requirement for maintenance plus 1 lb. gain.

Table II.

Calcium and phosphorus requirement for growing calves.

Body weight lb.	Morrison's standard*		Mitchell's standard**	
	Calcium g	Phosphorus g	Calcium g	Phosphorus g
100	7	6	4.1	4.7
200	13	10	5.5	7.5
400	13	12	11.7	13.8
600	13	12	14.5	18.4
800	13	12	20.4	21.6
1000	13	12	29.3	25.2

* Data from F.B.Morrison, 1959, Feeds and Feeding, p. 1088.

**Data from Scientific principles of feeding farm livestock- Proceedings of a conference held at Brighton, 1958, p.59-60.

In general, it is usually recommended that for maximum utilisation of calcium and phosphorus, the ratio of these minerals in the ration should be similar to that of bone i.e. 2.2:1. However, there are experiments to show that calves have grown equally well on rations with ca:P ratios from 6:1 to 1.2:1, but then adequate supply of vitamin D was made. This shows that in the presence of sufficient vitamin D, the ratio of Ca:P becomes of minor importance in the nutrition of calves.

The other minerals required for growing calves as stated earlier, are magnesium, sodium chloride and a few trace elements like Iron, Copper, Cobalt, Manganese and Iodine. The requirements of these are illustrated in table III.

Table III.

Mineral requirements (other than Ca & P) for calves*

Elements	Daily requirements	Particulars	Authority
Mg	16 mg	For 1.3 to 1.4 lb weight gain daily	Huffman et al. (1941)
	14 mg	With roughage of different mg contents.	Ray (1942)
	8 mg	For 0.7 lb weight gain daily	Blaxter et al. (1954)
	23 mg	To prevent hypo-magnesaemia	Thomas & Ohamoto (1954)
Na cl	11-16 g	On poor quality hay diet	Sheehy & Senior (1936)
Iron	25 mg	For 1 lb weight gain daily on whole milk diet	Blaxter et al. (1957)
	50 mg	For 2 lb weight gain daily on whole milk diet	" (1957)
	1.2 mg	For Hb value of 10 gm %	Matrone et al. (1957)
	16 mg	For 2 lb weight gain daily on whole milk diet	" (1957)
Copper	9 mg	On whole milk diet	" (1957)
Cobalt	0.1 mg	Per 100 lb livewt.	Filmer & Underwood (1937)
Mn	23 mg	Per 100 lb livewt.	Bentley & PHillips (1951)

3. Vitamin requirements for growth:- The chief vitamins concerned in growth are vitamin A, D and E. Of these the former two are of utmost importance.

The requirements of vitamin A are usually best expressed in terms of units of carotene, a precursor and a normal source of this vitamin for ruminants. Studies by Guilbert and Hart (1935) have shown that the calves require 1.5 mg of carotene per 100 lb body weight to prevent night blindness, but now this recommendation is considered to be insufficient. Boyer et al.(1942) have indicated that the requirement of carotene is about 4-5 times that of vitamin A itself and when there is poor conversion of carotene to vitamin A as is in case of Channel Island cattle, the requirement may be 30% still higher.

Lewis and Wilson(1945) have given the requirements of vitamin A for cattle based on different criteria as shown in table IV.

Table IV

Vitamin A requirements for cattle*:-

Criterian	Requirement per 100 lb. body weight (mg).
No Night blindness	0.4
Maximum growth rate	0.7
Maximum blood plasma level	5.8
Maximum liver storage	11.5

* Data from Scientific principles of feeding farm livestock- Proceedings of a conference held at Brighton, 1958, p.66.

The minimum requirement of vitamin D for growth and proper calcification of bones from birth to 7 months of age has been established at 300 U.S.P. daily per 100 lb. livewt. (Bechdel and associates, 1938). The N.R.C. recommendation is 300 I.U. per 100 lb. liveweight.

Systems of Calf Rearing:

Having a comprehensive idea of the nutritive requirements of growing calves, modern economic conditions have necessiated the adoption of several alternative methods of calf rearing, by which, at very low costs, dairy calves can be kept in health and made to grow faster with promising returns. Some of the methods generally recommended are discussed below.

Immediate Post-Natal Feeding:- After birth, care has to be taken to ensure that the calf is kept in a clean and hygenic surrounding. It is of the utmost importance that the calves get the first milk i.e. the colostrum or the beestings immediately after birth and then for the first 3 or 4 days of life. The colostrum, by virtue of its high anti-body content and richness in albumen and ash, guards the calves against a variety of diseases during their defenceless periods of life. The supply of colostrum is usually met when the calves are allowed to suckle their mothers as is common in rural India when they are fed artificially as practiced at most of the dairy cattle farms. After four days, the calves are maintained whole milk either by suckling or by pail feeding until they weaned.

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Feeding on Whole Milk:- No matter, what system of rearing is followed later, whole milk is indespensable for calves. But the rearing of calves on whole milk for a longer period requires a more critical attention. It is true that on whole milk feeding system, the calves may be expected to grow at the rate of 10-11 lbs. per head per week, but the use of whole milk alone for a longer period in calf rearing can not be justifiable except in very special circumstances, since the procedure proves to be an uneconomical one, particularly with ordinary commercial stocks (Woodman,1948). Therefore, modern feeding practices suggest the use of minimum amount of whole milk with maximum returns in terms of feed costs and rate of gain.

After the calves have been carefully schooled to have a good start on whole milk and have learnt to feed themselves, not less than about 5 lbs. of milk per head daily is required. This is increased gradually to a gallon or more per head per day if necessary till the calves are three months old. After this period, 1½ gallons per day suffices. Since whole milk feeding for a longer period is not an economical proposition, Lander (1949) has suggested that it should be discontinued only after a month, at which age the calves will be able to nibble hay and other leafy materials and take small quantities of crushed grain and finely ground oil cakes. According to Woodman (1948), the whole milk may be completely stopped only after the calves have become a fortnight old and milk substitutes continued thereafter in conjunction with a suitable calf meal.

Morrison in his Feeds and Feeding (1959) has suggested that in case of very valuable calves some whole milk may be given alongwith skim milk upto two months or even longer.

Sheehy (1955) has indicated that the whole milk feeding alone may be continued upto third week of life and thereafter it may be fed alongwith separated milk upto six weeks. After six weeks, the whole milk may be completely stopped and the calves changed to skim milk.

Roy (1958) has advocated that the initial daily maintenance requirements of calves of birth wt weights 60-100 lbs. are usually met by 4-6 lbs. of whole milk fed in smaller quantities at frequent intervals, while maintenance plus a daily weight gain of 1 lb. necessiates the supply of 6.5-8.5 lbs. of whole milk for the same liveweight range.

Feeding on Milk Substitutes:- The most commonly used milk substitutes are skimmed or separated milk and whey. Separated milk may gradually replace part of the whole milk, 3 lbs. of the former replacing 2 lbs. of the latter, until substitution has been completed (Lander,1949). When only skim milk is to be fed, only 14-16 lbs. of it daily is enough. In any case, the allowance should not exceed 18 lbs. daily until the calf is six weeks old (Morrison,1959). Since the separated milk has had most of its fat removed, some fat or oil is mixed with it to bring its value up to the whole milk. According to Woodman (1948), addition of about one-third lb. of fat or oil to one gallon of separated milk practically serves the purpose.

Lander(1949) has suggested to give some finely ground meal containing about 15% fat with some fish liver oil or 6-9 ozs of a mixture made up of 2 parts of crushed gram, 1 part of bran and 1 part of cake per head per day as an appropriate substitute for the fat.This gradually may be increased to 2 lbs at the end of fourth month. Morrison(1959) has also suggested that some cereal grains rich in carbohydrate and some good quality hay may be fed alongwith separated milk.

When neither skimed nor separated milk is available, the next preferable milk substitute is whey. But as it is devoid of most of its protein and fat,addition of $\frac{1}{4}$ lb of protein and $\frac{1}{3}$ lb of fat to 1 gallon of whey is necessary to bring its value upto the whole milk. This is achieved by adding some suitable grain mixtures to it in right quantities. Wisconsin studies have shown that calves have made normal growth when fed on whey at the rate of 14 lbs per head daily increased gradually from three weeks to six weeks age together with clover hay and a suitable grain mixture.

Feeding Calf Starters:- The method of raising calves on calf starters is largely adopted in Farms,where no milk bi-products are available. In this method the calves are given a good start on normal amounts of whole milk and are taught to eat a dry calf starter, or a calf meal and good quality hay as soon as possible.

A good calf starter has about 20% protein and a high T.D.N. value. Consequently,it should not have more than 5% of fibre.Some of the calf starters contain 15-16% of protein.

The calf starter is usually fed either as a gruel or as a dry meal. Woodman (1948), has reported that the calf starter was fed, during the war, as a gruel. This was prepared by adding 1 lb of the calf starter to 1 gallon of water which was then boiled for two minutes and finally cooled to 100^{0}F before feeding milk to the younger calves or fed as such to the older calves. Morrison (1959) has suggested that until the calf is three months old, the calf starter may be fed as a dry meal ad lib upto a maximum of 4-5 lbs a day with plenty of good hay. Feeding calf starter can be discontinued at the age of four months and some cheaper grain mixture fed alongwith good quality hay.

The daily schedule of milk and meal feeding to calves has been described by Lander (1949) as follows:-

First week:- Colostrum for 3-4 days, then 3 quarts whole milk daily in 2 feeds.

2nd week :- 3-4 quarts whole milk in 2 feeds daily.

3rd & 4th week:- Begin by feeding 3 quarts whole milk with 1 quart of gruel and a small quantity of dry mixk meal (cudlets) daily in 2 feeds. Gradually increase the proportion of gruel, ending with 1 quart whole milk, 3 quarts gruel and a little of cudlets. Introduced a little good hay. The cudlets should be placed in the bottom of the pail after each feed of gruel until the calf will feed from a trough.

5th, 6th & 7th weeks:- Give 4-5 quarts gruel daily in 2 feeds. Increase the cudlets to 1 lb per calf daily by the 7th week

and continue to offer a little good hay.

8th,9th & 10th weeks:- Reduce the quantity of gruel gradually and increase the quantity of hay and cudlets as the gruel is decreased . By this time, 2 to 2½ lbs of cudlets may be given daily. Six quarts of water should be allowed to drink daily to each calf.

The specifications of the composition of some of the calf starters have been furnished in table V, VI & VII.

Table V.

Specifications of the composition of national calf starters (cudlets & gruel) evolved by the Ministry of Food in England during the war(1942)*

Ingredients	Percentage by weight in the completed compound.	
	Cudlets	Gruel
Dried whey powder	29-31	29-31
Dried skim milk powder	14-16	14-16
Linseed cake meal	19-21	29-31
Linseed	4-6	4-6
Cane molasses	4-6	-
Fish meal	4-6	4-6
Wheat feed or flour	9-11	9-11
Oats	9-11	9-11
Dried grass meal	2-3	2-3
Calcium carbonate	1-1½	1-1½
Sodium chloride	½-1	½-1

* Data from F.E.Lander,1949,the Feeding of Farm Animals in India,p.334-336.

Table VI.

Calf starter formula as given by Morrison (1959).

	Ingredients		Parts by weight
(1)	Yellow corn	...	19.475
	Crushed oats	...	20.0
	Wheat bran	...	15.0
	Linseed meal	...	10.0
	Dried skim milk	...	5.0
	Soybean oil meal	...	14.0
	Cane molasses	...	5.0
	Alfalfa meal	...	7.0
	Brewer's yeast	...	3.0
	Irradiated yeast	...	0.025
	Ground lime stone	...	0.5
	Steamed bone meal	...	0.5
	Iodized salt	...	0.5

Table VII.

(2)	Yellow corn meal	...	24.775
	Crushed oats	...	20.0
	Wheat bran	...	15.0
	Linseed meal	...	10.0
	Soybean oil meal	...	18.2
	Cane molasses	...	5.0
	Alfalfa meal	...	5.0
	Irradiated yeast	...	0.025
	Ground lime stone	...	0.5
	Bone meal	...	1.0
	Salt	...	0.5

Some of the systems of raising dairy calves as followed at different farms are as follows:-

Feeding Schedule followed in Ireland as described by Sheehy (1955).

1st week:- 6 pints of whole milk increasing to 8 pints.

2nd week:- 8 " " " 10 "

3rd week:- 10 " " " 12 "

4th week:- 8 pints of whole milk & 4 pints separated skim.

5th week:- 4 " " 8 " "

6th week:- 2 " " 10 " "

7th to 10th week:- 12 pints separated skim.

After 10th week, separated milk, in smaller or larger quantity as available, is fed. When separated ~~is~~ milk is not available, calf starter is to be fed alongwith normal amounts of whole milk.

Lander (1949) has described the following rationing schemes followed at the Imperial Agricultural Research Institute, New Delhi and by the Military Dairy Farms in India as shown in table VIII & IX respectively. It should be mentioned here that the milk, at the Imperial Agricultural Research Institute is fed at body temperature ~~f~~ from its own mother to the calf three times daily till the calf is one month old. After a month, it is fed twice daily. Common salt and mineral salt is also provided. Rock salts are kept for licking at will.

Table VIII.

Details of calf feeding system followed at the Imperial Agricultural Research Institute, New Delhi*

Age	Whole milk lb	Skim milk lb	Grain lb	Salt Oz.
1-3 weeks	1/10th of the bodywt.	-	-	-
4-5 weeks	-do- + ½	-	-	-
6-8 weeks	-do- + 1	-	½	1
9-10 weeks	-do- + 1½	-	½	1
11-12 "	-do- + 2	-	½	1
13-16 "	-do- + 3	-	¾	1
17-20 "	-do- + 3½	2	1½	1
21-26 "	-do- + 2½	4	2	1
27-30 "	-do- + 3	4	2½	1
31-34 "	-	6	2½	1

* Data from P.E.Lander (1949), the feeding of farm animals in India, p.331.

Table IX

Rationing scheme followed by the Military Dairy Farms, India, for cow calves.

Age	Dam's colostrum lb	Whole milk lb	Separated milk lb	Concentrates lb.	Fodder	Times of feeding
1	2	3	4	5	6	7
Ist-3rd day	1.0	-	-	-	-	4
4th-7th day	-	1.0	-	-	-	3
2nd-3rd Wk.	-	1.25	-	-	-	2
4th week	-	0.75	0.25	1/20	-	2
5th "	-	0.75	0.25	1/20	1/20	2

Continued...

Table IX. contd.

1	2	3	4	5	6	7
6th week	-	0.75	0.25	1/20	1/10	2
7th-8th wk.	-	0.50	0.40	1/12	1/8	2
9th week	-	0.50	0.40	1/12	1/6	2
10th-12th wk.	-	0.30	0.50	1/12	1/5	2
13-16th wk.	-	0.10	0.50	1/12	1/5	2
17-19th wk.	-	-	0.40	1/12	1/4	2
20-23rd wk.	-	-	0.25	1/12	1/3	2
24-26th wk.	-	-	0.10	1/12	1/2	2

* Data from P.E.Lander (1949), The Feeding Of Farm Animals in India, Appendix V.

Note:- 1. The figures above under all heads, except fodder, denote the quantity to be fed for every 10 lbs. body weight (5 lbs. & over to be counted as 10 lbs, under 5 lbs to be ignored).

2. The g figures under fodder show the actual proportion of the standard fodder ration to be fed.

3. When separated milk is not available, it is replaced by 50% whole milk at all the young stock farms.

Use of Antibiotics in Calf Nutrition:- Our knowledge of the use of Antibiotics in calf nutrition has been of very recent origin. It is now said that when the calves are raised by calf starter method, good results are obtained if whole milk feeding is continued up to 7 to 10 weeks of age, and that the results are more pronounced if an effective Antibiotic

is fed to the calves along with the milk. Although, the reports are contradictory, but there are experiments to show that if an effective Antibiotic is added to the milk, milk feeding may be discontinued as early as 5 weeks with satisfactory results.

Maynard (1956) has reported that rations containing antibiotics improve the early growth of calves and the amount of feed consumed per pound gain is often smaller. The effect is more pronounced when the antibiotics are fed directly instead of adding them to the grain mixtures, probably because the calves do not eat much grain before they cross 3 to 4 weeks of age. Usually, 20 g of antibiotics per ton of grain mixtures are used, but feeding 10 mg daily per calf in milk gives results equal to larger intakes as found at Cornell University.

Reid and associates (1954) have reported that in general feeding 10 to 100 mg of antibiotics daily to dairy calves during the first 2 to 4 months increased the gain in body weight by 10 to 30 % compared with calves not receiving the antibiotics. Chlortetracycline and oxytetracycline have greatest value for calves. Penicilline is the least effective. How far the use of these antibiotics can be successful in practical calf rearing, is still a matter of further investigation.

STUDIES RELATED TO GROWTH RATE & FEED ECONOMY

CATTLE:- Sayer (1934) conducted an experiment with Sahiwal breed heifers, in which he placed 2 groups of the latter on two different feeding regimes. One group was placed on the ordinary farm diet, whereas the other group of more or less similar age and body weight was placed on a special diet made up of an extra amount of milk and some change in the concentrate mixture. At the end of 26th week the average daily gain of Sahiwal heifer calves fed on ordinary farm diet was 1.03 lb, whereas in case of the group on special diet, it was 1.21 lb. Sayer has drawn attention to an interesting fact that there are certain definite periods in the calf feeding life which have a direct bearing on its future development.

Vishwanath (1941) has reported that under a good system of feeding, heifer calves could be brought to the age of maturity within the age of 19 months, which is considerably less than the usual age of 2½-3 years as is common in most part of India.

Lofgreen, Loosli & Maynard (1951) working with Holstein heifers have shown that there was a significant increase in the efficiency of utilization of Nitrogen available above the maintainance requirements when the calves received a low protein diet but 20 percent more T.D.N. An increase in the energy intake with a high protein level did not bring any increase in nitrogen retention. In case of calves getting a high protein but low

energy ration, there was also a significant increase in nitrogen retention, but the efficiency of gain was lowered. No significant difference in weight gains on low or high protein levels with low energy intake was obtained. These workers have concluded that there is no advantage in giving extra protein to Holstein heifers from 150 to 350 lbs liveweight than recommended in 1936 Morrison standard, but for heifers weighing more than 700 lbs, Morrison's standard was found to be in excess.

Mullick & Kehar (1952) studied the seasonal variations in the pulse rate, respiration rate, body temperature and body weight in normal Indian cattle. They observed a decreased body weight in summer months and the correlation coefficient showed that there was a significant interrelationship between the atmos%-pheric temperature and liveweight. They explained it to be possibly due to differences in the food intakes under different environmental conditions. K. Raju (1953) has also reported a decrease in the average weights during summer owing to reduced food intake.

Hibbs et al. (1953) worked on 17 Jersey calves aged 3 days upto 10 weeks of age. 2 groups received a simple concentrate mixture containing 14.4 % total protein and 2 groups received a complex concentrate mixture containing 25% total protein. Hay was fed to both groups ad lib & adjustments were made to keep the Hay:concentrate ratio 2:1

all the time. After 10 weeks, the male calves were slaughtered and the experiment with the female calves was carried on upto 6 months of age. It was observed that the rate of gain and efficiency of food utilisation was higher in simple grain group at 10 weeks than the complex grain groups.

Alexander (1954) working with the level of feeding of calves has shown that the group of calves getting 40,30,25,20, & 15 gallons of milk and equal amount of a concentrate (20% crude protein) upto 12 weeks gave an average weekly gain of 7.6,6.1,5.5,5.3 and 4.8 lbs.respectively.

Brown et al.(1958)have reported that rate of gain and efficiency of feed conversion were higher in calves getting sixteen percent crude protein than those given higher or lower levels than this. Apparent digestibility of protein varied inversely with the percentage of protein in the diet. Similar results have been obtained by Kesler & Wilson (1958).

Everette (Jr.) et al. (1958) in a trial with 60 calves have shown that the rate of gain was higher with higher levels of protein in the diet. So was the case with nitrogen retention.

Recently, Talapatra (1962) in a personal communication to the author has reported the findings of his two

students on growth studies in Hariana calves. Roy (1961) has observed that growth rate as high as 1.7 lb per head per day could be obtained in Hariana calves under a special feeding regime. The work of Yamdagni (1962) with calves of the same breed has shown that special feeding and management was responsible for a daily gain of 1.9 lb per head and that the calves were able to ejaculate good quality semen as early as at the age of 19-20 months.

PIGS:- Becker, Lassiter, Terrill & Norton(1954) conducted 2 experiments on pigs. In the Ist experiment, the group of pigs received 10, 12, 14, & 16 % of protein in the diets and in the 2nd experiment, the other 4 groups received 12, 14, 16 & 18 % of protein in their diets. The protein sources were from corn Soybean oil meal and corn-Menhaden fish meal in both the experiments. At the end of the experiment the workers found that pigs from 40 to 100 lbs required a minimum of 14% protein in corn Soybean meal ration and a minimum of 16% protein in corn-Menhaden fish meal ration. From 100 - 200 lbs liveweight, the requirement was 12% protein.

Smith & Lucas (1956) using 4 different levels of protein(24, 29, 34, & 39%) with baby pigs have shown that an increase in dietary crude protein from 24 to either 29, 34 or 39 % in the diet significantly improved feed conversion efficiency, but not growth rate. The differences in feed conversion efficiency in each case over the 24% protein

level were 10, 12, & 13% respectively.

Jensen et al. (1957) worked on the effect of different levels of protein (14.4 % to 27.6%) with pigs weaned at 2 weeks of age and reported that rate of gain and feed efficiency rose with level of protein rising . In another trial also in which they compared 10 to 32% levels of protein, similar results were obtained. But in each case, a protein level of 16.6% was found to be most economic as regards growth rate and feed conversion efficiency. Highest level of protein (28 & 32%) were found to give more or less similar results as 17% protein.

Rutledge, Hanson & Meade (1961) while studying the protein requirements of suckling age pigs have reported that the levels of protein ranging from 17 to 27.6% had no significant effect on the average final weight of the pigs, but there was a definite trend towards more efficient utilisation of food for gain as the level of dietary protein increased. Significant difference was obtained as regards nitrogen retention, less nitrogen being retained by pigs receiving 17% protein than those fed other levels.

Aunan, Hanson & Meade (1961) in 4 experiments with different breeds of pig have reported that 14, 16 & 18% proteins gave better results than 12% protein level as regards acceleration of growth rate. There was no significant difference between 14, 16 & 18% levels. Marked variation was noticed in daily gains and carcass quality due to breed effects.

POULTRY:- As early as 1930, Norris and Heuser conducted two experiments with W.L.H. chicks using four groups each time. In the first experiment, each of the four groups contained 39 and in the second experiment, each of the four groups contained 70 W.L.H. chicks. The percentage of protein and the protein - energy ratios tried in the two experiments are shown in table X below.

Table X.

Table showing the percentage of protein & the protein - energy ratios used in the 2 experiments*

Lot	Protein %		Protein-energy ratio	
	Experiment I	Experiment II	Experiment I	Experiment II
A	20.90	20.23	1:3.01	1:3.17
B	18.58	17.93	1:3.50	1:3.69
C	16.76	15.49	1:4.0	1:4.41
D	15.20	12.87	1:5.0	1:5.5

* Data from L.C.Norris & G.F.Heuser, Poultry Sci., 1930, 9:, 378-392.

The workers obtained the best growth in lot A & poorest in lot D of the first experiment. The other lots ranged between A & D. In experiment 2, similar results were obtained upto 8 weeks of age, but at 20 weeks, the relative differences in growth between lots A & B, and B & C were much less than at 8 weeks.

The most efficient utilisation of protein was obtained from the low protein rations in both the experiments. Each added increament of protein above these low

levels produced smaller and smaller returns in terms of growth. The possible explanation given for this fact was that the optimum supplementary relationship between the proteins of the mixtures was upset due to increased increaments of proteins resulting in reduced efficiency of protein utilisation. On the other hand, the efficiency of feed utilisation increased with each increament of protein.

Day & Hill (1956) experimented with different levels of protein ranging from 24.3 to 32.1 % in turkeys. The diets had the same energy content per lb (842 Cal). It was noted that growth and feed efficiency progressively increased as the protein content rose to 30.1 % with energy-protein ratio 2·8:1. There was no significant difference in weight gain and efficiency of feed conversion within the groups getting the same level of energy, but the birds on the high energy ration were heavier than those on low energy ration and efficiency was also better.

Carter et al.(1957) using 14,17,20 & 23% protein and different levels of energy in the rations of turkeys have shown that efficiency of feed conversion increased with each protein level as the energy value of the ration increased.

Reed & Valu (1957) working with 22 & 30 % crude protein rations in poultry reported that the feed conversion efficiency was higher in ration containing 30% protein. The total egg production on high and low protein rations was 2199 and 1636 respectively. The feed utilised per dozen of egg on high & low protein ration were 8.6 & 11.1 lbs respectively.

RATS:- Slonaker (1931) experimented on the effect of different levels of protein ranging from 10.3 to 26.3% and equal amounts of energy per g of feeds (3.82 Cal) fed to rats. The results obtained indicated that the diets containing just over 14% protein gave the best result for growth. When the intake of protein was either sub-optimal or exceeded the optimum, progressive retardation in growth took place.

Forbes, Swift & associates (1935) placed four groups of rats on 4 feeds containing different levels of protein (10,15,20 & 25%) and equal amount of energy in each case. After a 10 week experimental period, it was observed that with constant energy intake, the increase in the percentage of protein led to a greater increase in body weight. 10 to 15% levels were more effective than either 15 or 20% level in this respect. The digestibility of both the protein and energy producing nutrients increased slightly but consistently with increase in the plane of protein intake, but the metabolizable energy of the diets was essentially the same at all planes of protein intake. This was reported to be due to the fact that the urinary energy increased almost exactly in proportion as the fecal energy decreased with rise in propotion of protein in the diets.

Johnson,Hogan & Ashworth (1936) compared 10% & 25% proteins in rats and reported that the growth rate was higher with high protein diets.

Forbes et al.(1937) comapred 25 to 45% proteins in rats and found that with same food intake,the progressively greater protein contents of the diets above 25% resulted in diminished gains in body weights, because of lower metabolizibility of the protein than non-nitrogenous organic nutrients. These workers have come to conclusion that any further increase in the protein beyond the optimum impairs the nutritive balances of the diets as sources of energy resulting in decreased utilisation of energy for body gain due to more rapid decrease in metabolizable energy than in heat production, the latter being so due to an increase in the urinary energy which slightly exceeds the slight decrease in the fecal energy.

Barnes & associates (1946) working on 28 groups of albino rats with 4 crude protein sources have concluded that the increase in the level of protein increased the protein utilization and this enhanced the growth rate until a maximum was reached. Beyond this maximum level, they have shown that any excess of protein is rapidly deaminized with a consequent rise in exogenous urinary nitrogen and an increase in specific dynamic heat loss. This also accounts for the lowered Biological value.As for example, the whole egg protein at 38 g of intake had 100% Biological value,but only 60% at 70 g of intake, the remaining 40% being metabolized for other purposes.

STUDIES RELATED TO BLOOD COMPOSITION.

Considerable amount of work have been done in connection with the important blood constituents of different species of animals in Foreign countries and to some extent in India, but literatures pertaining to the studies of these phenomena in growing calves rather seem to be very meagre. Thus, the literatures cited here in this respect relate mostly to the studies on the normal composition and seasonal variations in the important constituents of blood in case of different catagories of cattle.

Normal Composition of Blood:- Considerable amount of data on the normal levels of important blood constituents of Indian cattle are available. These are summerised in the table XI below.

Table XI.

Statement showing the average blood composition of normal Indian cattle.

Animals	Cal. mg% Serum	I.Ph. mg% serum	Sugar mg% blood	Haemo-globin g % blood	Total protein g % serum	N.P.N. mg% blood	Reference
Kumaoni Bullocks	10.5 ± 0.10	6.8 ± 0.20	88.1 ± 2.06	7.4 ± 0.18	6.79 ± 0.25	-	Kehar & Murthy (1952)
Hariana Bullocks	10.4	4.26	75.6	10.8	8.61	-	-do-(1948)
-do-	10.5	4.04*	82.6	10.8	-	-	Mullick & Pal (1943)
Hariana Cows	11.4	4.32*	77.7	10.9	-	-	-do- -do-
Hariana Calves	13.0	5.92*	99.9	14.6	-	-	-do- -do-
Dhani Bullocks	11.1	5.56*	88.3	12.5	-	-	-do- -do-

* The values indicate mg.% of blood.

Sen & Roy (1933) estimated the total protein content of the blood of 28 hill bulls and reported a value ranging from 6.0621 to 9.0470 g per 100 c.c. of the serum.

Kehar (1940) estimated the total protein and non-protein nitrogen content of blood in 6 normal Indian cows and the average value of the two was reported to be 9.34 g per 100 c.c. of serum and 0.79 g per 100 c.c. of blood respectively.

Kehar & Murthy (1951) studied the blood picture of buffaloes (bullocks). The findings of these workers were as follows:-

Calcium	...	10.0 ± 0.09 mg% of serum
Inorg.Phosphorus		6.95 ± 0.05 mg% of serum
Sugar	...	79.4 ± 3.1 mg% of blood
Haemoglobin	...	7.7 ± 0.22 g % of blood
Total protein	...	7.46 ± 0.09 g % of blood

Rusoff & Frye (Jr) (1951) studied the blood of 16 Red Sindhi- Jersey daughters and their 16 Jersey dams all on a high plane of nutrition and obtained the following values for some of the constituents.

Ingredients	Jersey cows	Red Sindhi-Jersey daughters
Serum calcium(mg%)	9.6 ± 0.06	9.63 ± 0.07
Serum Phosphorus(mg%)	5.38 ± 0.04	7.58 ± 0.08
Haemoglobin(g% blood)	9.6 ± 0.05	10.26 ± 0.06

These workers also reported a decline in the Calcium and Phosphorus values with advancement of age.

Byers et al.(1952) studied the blood Haemoglobin value of Holstein, Jersey and Grade cattle at different ages. The average value of Haemoglobin for the three was found to be 11.1 g %. There was no significant difference between various ages and sexes but a significant difference was obtained between the average value of Holstein & Jersey breeds, the average being 10.6 & 11.3 g% respectively.

Reda & Salem (1954) estimated the serum calcium in the blood of Egyptian cattle, Egyptian buffaloe and crossbred cattle and obtained the following results:-

Egyptian cattle - 9.2 mg%

Egyptian buff. - 10.0 mg%

Crossbred cattle - 8.5 mg%

Rusoff et al.(1954) studied the blood of Jersey, Guerensy & Holstein bulls for over one year under the same managements and feeding and obtained the following results:-

Ingredients	Jersey	Guerensy	Holstein
Haemoglobin(g%)	11.6 ± 0.2	12.2 ±0.2	11.6 ± 0.15
Serum calcium (mg%)	10.47± 0.24	10.21 ±0.2	10.26 ±0.22
Serum Phos.(mg%)	4.55± 0.11	4.86 ±0.14	4.51 ±0.09

They also reported a decrease in the Haemoglobin and Phosphorus levels with age.

<u>Studies On The Seasonal Variation in Blood Composition:-</u>

Pal, Momin & Mullick (1945) studied the seasonal variation in the composition of blood and sera of normal

adult Hariana cows. The findings of these workers for four months (April-July) corresponding to the present experimental period are shown in table XII below:-

Table XII.

Seasonal variation in the blood & Sera of Hariana Cows.*

Ingredients	April	May	June	July
Serum calcium(mg%)	10.7	11.5	11.5	11.3
Serum Phosphorus (mg%)	4.81	4.37	4.46	4.43
Blood Sugar (mg%)	80.5	80.0	80.6	80.6
Haemoglobin (g%)	10.0	9.9	9.8	10.1
Total protein(g%) (Serum)	7.3	7.4	7.4	7.4
N.P.N.(mg %blood)	35.6	36.5	36.5	37.7

* Data from A.K.Pal,S.A.Momin & D.N.Mullick(1945),Indian J.Vet.Sci., 21:,13.

Note:- The figures above are the averages of 12 animals.

Sagar (1962) studied the seasonal variation in the Haemoglobin content of the blood of dairy cattle of Allahabad Agricultural Institute. It was revealed that Haemoglobin concentration in all the animals was higher during summer than in winter, as shown in table XIII.

Table XIII.

Average blood Hb.content in cattle during summer season*

Periods	Milch cows	Dry cows	Young stock	Bulls
July-Sept.	9.68	10.22	9.51	10.22
March-June	9.53	11.36	10.20	12.25

* Data from R.H.Sagar,The Ind.Vet.J.,39:,158,1962.

Raghavan & Mullick (1962) studied the effects of air temperature and humidity on the blood composition in buffaloe bulls and reported a higher value of calcium during summer months and an irregular relation with the change in atmospheric conditions of Phosphorus, Sugar, Haemoglobin, Serum total protein & non-protein nitrogen. The values for these constituents under the minimum and maximum height of temperatures are shown in table XIV.

Table XIV.

Composition of blood at different temperatures*

Ingredients	52°F	94°F	106°F	104°F
Serum calcium(mg%)	9.84 ± 1.18	11.10 ± 1.17	10.50 ± 1.48	10.77 ± 1.46
Serum Inor.P.(mg%)	6.90 ± 2.06	6.19 ± 6.46	5.11 ± 0.90	6.08 ± 0.98
Blood Sugar (mg%)	52.60 ± 4.54	43.50 ± 5.04	42.50 ± 5.12	40.80 ± 2.89
Haemoglobin (g%)	15.79 ± 2.09	11.18 ± 1.46	11.79 ± 1.12	11.79 ± 1.12
Serum total protein (g%)	6.79 ± 0.35	6.18 ± 0.34	6.31 ± 0.38	6.44 ± 0.60
N.P.N. (mg%)	41.22 ± 1.25	41.28 ± 2.41	42.69 ± 2.45	43.22 ± 3.00

* Data from G.V.Raghavan,& D.N.Mullick,Ind.J.Dairy Sci., 1962, 15:, 61-67.

Seshiah (1962) studied the blood levels of domesmm tic animals maintained under different planes of nutrition and reported the following figures for cows and bullocks.

	Serum Ca(mg%)	Serum Inor.P(mg%)
Cows upto 6 years	10.39	6.39
Cows above 6 years	8.87	6.23
Bullocks	9.60	5.86

****

CHAPTER III

MATERIALS AND METHODS.

Experimental Animals:-The animals used for this study were 12 Tharparkar calves obtained from the Government Cattle Farm, Patna. The selection of these calves was done on the basis of similarity of age. Thereafter, the calves were weighed just on the day of commencement of the experiment and divided into two groups in such a way so as to provide similarity in the average age and weight of the two groups. The details of their age, body weights and distribution in the two groups are furnished in table XV.

Table XV

Table showing the details of selection and distribution of calves in the two groups.

Groups	Sl. No.	Calf No.	Sex	Date of birth	Age on the day of selection	Weight on the day of distribution in the group
I	1	110/61	Male	12.10.61	172 days	75 Kg.
	2	114/61	Female	20.10.61	164 "	62 "
	3	115/61	Male	23.10.61	161 "	72 "
	4	116/61	Male	23.10.61	161 "	52 "
	5	118/61	Female	26.10.61	158 "	75 "
	6	124/61	Male	19.11.61	135 "	43 "
II	1	111/61	Male	12.10.61	172 "	65 "
	2	112/61	Female	18.10.61	166 "	52 "
	3	113/61	Female	20.10.61	164 "	64 "
	4	117/61	Male	24.10.61	160 "	56 "
	5	119/61	Male	26.10.61	158 "	72 "
	6	120/61	Male	26.10.61	158 "	68 "

It is seen that the average age of calves in group one is 158.5 days and the average weight is 63 Kg. In group two, the average age of the calves is 163 days and the average body weight is 63 Kg.

The group one was designated as "Control group" because the calves under this group were fed the ration used at the farm (called control ration hereafter) while group II was designated as "Experimental group" because the calves under this group received a ration made up of the same ingredients as the control ration, but in different proportions and furnishing an equal amount of energy and 25% less D.C.P. per pound than the control ration.

The Feeds & Their Analyses :- The feeds constituting the concentrate mixture used at the farm and thus adopted in this experiment were wheat bran, groundnut cake, gram crushed and salt. Therefore, in order to know the nutritive value of the individual feeds and thereby to compute the rations for the two groups, all the individual feeds including spear grass hay and green para grass were analysed prior to starting the actual experimental feeding. In order to determine the T.D.N. value of these feeds, the digestion coefficient of each of the nutrients were presumed to be that given by Indian workers failing which Morrison's data were utilised.

For analysis of the feeds, 50 samples of each feed were collected from 10 different bags, taking about 10 g at a time from 5 different places of each bag in

order to get a representative sample of the feed. Thus for each feed, a sample of about 500 g was procured. The bulk of the each such sample was thoroughly mixed for different analyses.

The analysis of the feed was done by the following methods:-

Protein:- By Kjeldahl method as given in A.O.A.C. methods.

Crude fibre:- By Windee method as given in A.O.A.C.methods.

Ether extract:- By Soxehelet extration for 48 hours.

All analyses were made in duplicate. The results of the analysis have been furnished in the chapter "RESULTS".

Computation Of Ration:- Having calculated the nutritive value of the individual feeds, two types of ration were prepared - one, the control ration to be fed to the control group and the other, experimental ration for the experimental group.

The composition of the control ration used at the farm and adopted in this experiment was as follows:-

Wheat bran	...	9 parts.
Groundnut cake	..	9 "
Gram crushed	...	8 "
Salt	...	2 "

This mixture furnished per pound 0.87 lb of dry matter, 0.173 lb of D.C.P. and 0.68 lb of T.D.N.

The composition of the experimental ration was formulated to be as follows:-

Wheat bran	...	13.25 parts
Groundnut cake	..	3.50 "

Continued....

Gram crushed ... 9.25 "

Salt ... 2.00 "

This mixture furnished per pound 0.875 lb of dry matter, 0.131 lb of D.C.P. and 0.677 lb of T.D.N. thereby providing the same amount of D.M. and T.D.N. as the control ration, but 24.5 % less D.C.P. on per lb basis.

Feeding Practice Followed During The Experimental Period:- The usual practice of feeding the calves at this farm is to feed them in groups. The calves aged 0-1 month are fed in one group, while those aged 1-6 months are fed together. The practice in vogue to feed the calves in the farm is shown in table XVI.

Table XVI.

System of feeding calves upto 6 months followed at the Government Cattle Farm, Patna.

Age	Cow milk	Concentrate mixture	Green grass
0 - 1 week	4 lb	-	-
1 wk - 1 month	8 lb	-	-
1 month-4 "	6 lb	20 Kg for a group consisting of 60 calves of 1-6 months age.	Ad lib.
4 " -6 "	4 lb		

It is apparent that calves aging 1-6 months are fed the concentrate mixture and greens in one lot. The feeding of milk and grain is done 2 times daily half of the allowances given at one time. Milk feeding is discontinued when the calves have reached the age of 6 months and they are transferred to another pens where their mode of feeding becomes different henceforward.

The general practice of feeding the experimental animals in this experiment was that the control group was allowed the average of the maximum and minimum allowances of D.C.P. & T.D.N. as recommended in the Morrison's feeding standard for a given body weight of a growing calf, while the experimental group was allowed the same amount of D.M. & T.D.N. in the concentrate mixture as the control group, but received 24.5% less D.C.P. The amount of concentrate was increased by ½ lb per head in both the groups at an interval of every three weeks to provide for the increased body weight. Mineral mixture (I.C.I.) was fed to both the groups in the ratio of 1 lb of mineral mixture to every 30 lbs of the concentrate mixture.

Green para grass (allowed after a month) and hay were fed to both the groups ad lib provided in a 50-50 ratio in weighed quantities and daily consumption of these recorded. Any concentrate, if left over, was also weighed to determine the actual consumption on that day.

The calves were fed in groups in closed pens (two groups fed separately). Four hours exercise (two hours morning and two hours evening) was allowed to both the groups daily without access to any grazing. The timing of feeding was maintained throughout the experimental period as follows:-

Concentrate mixtures .... 8 A.M. daily
Para grass and hay ....12 noon daily
Concentrate mixture ....4.30 P.M. daily
Water .... 3 times daily

Prior to taking up the actual experimental feeding, a 5 days preliminary period was allowed during which the milk was gradually withdrawn and the quantity of hay and concentrate increased. This also gave an idea regarding the actual dry matter intake by each calf from the feeds to be used in the experiment.

Weighing of Calves:- The calves were initially weighed just on the day of commencement of the experimental period and then after every week. The weighing was done at about 7 A.M. at each occasion before giving any food or water to the calves. The details of weighing data have been presented under the chapter "RESULTS".

In the latter part of June, 1962, one calf of the control group began to show the symptoms of general debility, weight loss and weakness and therefore, it was removed from the lot. Consequently, the control group henceforward consisted of only 5 calves - 3 males and 2 females.

The growth rate has been expressed as average growth rate by the formula $\frac{W_2-W_1}{T_2-T_1}$, where W_1 is the initial weight, W_2 is the final weight and T_2-T_1 is the time interval (Pomroy, 1955). The growth rate of the two groups has been furnished under the chapter "RESULTS".

Collection of Blood Samples:- The blood samples were collected from the Jugular Vein of each calf in early morning (7.30 A.M.) on the day of collection (every fortnight). Two samples were collected from each calf- one,oxalated for estimation of sugar,haemoglobin & non-protein nitrogen, and the other sample was taken for obtaining serum for estimation of calcium, inorganic-phosphorus and total protein.

The anti-coagulants used in this experiment consisted of 1% solution of Ammonium oxalate and 1% solution of Potassium oxalate. 0.6 c.c. of Ammonium oxalate and 0.4 c.c. of Potassium oxalate when taken together was found to be sufficient to keep 5 c.c. of blood in normal condition even up to 3 to 4 days under referigeration.

After collection, sugar and haemoglobin were immediately analysed and the remainder of the samples kept in referigerator for other estimations after-wards.

Analysis Of Blood Samples:- As stated earlier, the analysis of blood was confined to (a) serum calcium, (b) serum inorganicphosphorus,(c) ~~xy~~ sugar,(d)haemoglobin, (e) total protein and (f) non-protein nitrogen. The methods adopted for the analysis of these constituents of the blood have been described below. Here it is essential to mention that prior to taking up the actual estimation, a few preliminary estimations for these were made in blood

samples collected from goats, cows, horses and also in the A.R.P. serum obtained from the local Livestock Research Station. The methods for estimation of sugar and phosphorus were further critically tested by recovery experiments which invariably gave over 94% recovery. The methods for estimation of the various blood constituents were as follows:-

(a) Serum calcium:- Clark - collip modification of the Tidsall method (1925):- 2 c.c. of blood serum was taken in ungraduated test tubes to which was added 2 c.c. of distilled water and 1 c.c. of 4% Ammonium oxalate. This gave a precipitate of calcium -oxalate. Several rotatory movements were given to facilitate precipitation and left for ½ an hour for the purpose.

Now, the contents were centrifuged for 5 minutes at the rate of 1500 revolutions per minute. Then the supernatant fluids were drained out carefully and 3 c.c. of dilute ammonia (2 c.c. of ammonia in 98 c.c. of distilled water) was added to the contents and mixed by rotatory movements as before. The contents were again centrifuged for 5 minutes as before. The supernatant fluids were drained out by downward inversion of the tubes and the latter were kept on dry filter paper downward for drying.

Then, 2 c.c. of normal H_2SO_4 was added by blowing it directly on the precipitate. The mixture was boiled for 10 minutes in a waterbath and titrated against $\frac{N}{100}$ Potassium per manganate, care being taken that the tube

remained hot during tiration. End point was reached when a pink colour lasting for about a minute was obtained. The mean of the two such titrations was taken. Let it be X.

A blank test was also done by titrating 2 c.c. of normal H_2SO_4 with N/100 Potassium per-manganate with a view to ascertain the purity of the acid. Let it be Y.

Calculation:-

$\therefore$ 1 c.c. of N/100 $KMnO_4$ $\equiv$ 0.2 mg of calcium,

$\therefore$ (X-Y) c.c. " " $\equiv$ (X-y)x 0.2 mg "

$\therefore$ 100 c.c. of " " $\equiv \frac{(X-Y)x\ 0.2x100}{2}$ mg ca.

(b) Serum inorganic phosphorus:- Method of Fiske and Subba-Row (1925):- 6 c.c. of 13.3% trichloro-acetic acid was taken in two test tubes to which was added 2 c.c. of blood serum. Mixed well and allowed to stand for ½ an hour to facilitate precipitation. Then, filtered through a dry ashless filter paper(Phosphorus free) washing the tubes with 2 c.c. of distilled water twice and filtering it also.

5 c.c. of the filterate was taken in another test tubes and added one by one 1 c.c. of molybdate II, 3.6 c.c. of distilled water and 0.4 c.c. of Amino-naphtho-sulphonic acid. Mixed well by inversion and allowed to stand for colour development and read in the colorimeter.

5 c.c. of a previously prepared standard phosphate solution was taken in a hundred c.c. volumetric flask to which added one by one 10 c.c. of molybdate I,

50 c.c. of distilled water and 4 c.c. of Amino-naphtho-Sulphonic acid. Mixed well by inversion, allowed to stand for 10 minutes and then read in the Colorimeter.

Calculation:- Percentage of Inorganic Phosphorus in the serum is equal to,

$$\frac{\text{Reading of unknown} \times 0.04 \times 100}{\text{Reading of standard.}}$$

(c) Blood Sugar:- Hagedorn and Jensen Method (1923) :- 1 c.c. of N/10 Na OH & 5 c.c. of 0.45% Zink Sulphate solutions were taken in a test tube (15 x 150m.m.). A gelatinous precipitate of Zink Hydroxide was formed. Then added 0.1 c.c. of oxalated whole blood from a capillary pipette, the pipette being washed out twice with the mixture and blown empty. The tube was put in a boiling water-bath for three minutes. Then the mixture was filtered through a fine filter paper previously moistened with distilled water in another test tube(30x90m.m.) wahing the original tube with three c.c. of distilled water twice and filtering it also.

To the filterate, added 2 c.c. of alkaline potassium ferricyanide solution and heated in a boiling water-bath for 15 minutes. Cooled under tap, mixed 3 c.c. of Iodide-Sulphate solution and 2 c.c. of 3% Acetic acid solution and titrated it with N/200 Sodium Thio-sulphate solution (taken in a micro-burette) using 2 drops of 1% starch solution prepared in saturated NaCl solution. The end point was ascertained by the complete disappearance

of the voilet colour. The mean of two such titration readings were taken for each sample. Let it be X.

A blank test was also done by carrying through the whole determination but without the addition of blood. Let this titration reading be Y.

Calculation:- From the chart furnished in the practical Biochemistry by Hawk, Osser and Summerson, the glucose values corresponding to the Thio-sulphate readings(X & Y) were noted down and the percentage of sugar in the blood was determined by multiplying the difference between the glucose value of X & Y by 1000. The result was obtained in terms of mg of sugar in 100 c.c. of blood.

(d) Haemoglobin:- Wong Method(1928) :- 0.5 c.c. of oxalated whole blood was taken in a 50 c.c. volumetric flask and to it added 2 c.c. of Iron free concentrated H_2SO_4 . Mixed by whirling for 10 minutes, added 2 c.c. of saturated potassium per-sulphate solution, diluted to 25 c.c. with distilled water, added 2 c.c. of 10% sodium tungstate solution and again mixed well. Cooled under tap, diluted to 50 c.c. with distilled water, stoppered and mixed by inversion. Filtered through a dry filter paper (No.42) and collected the filtrate in a dry flask.

For standard, taken 25 c.c. of distilled water in a 50 c.c. volumetric flask and added one by one 2 c.c. of Conc. H_2SO_4, 2 c.c. of saturated potassium per-sulphate & 2.5 c.c. of previously prepared standard Iron solution containing 0.1 mg of Ferric Iron per c.c. Cooled to room

temperature, made the volum 50 c.c. with distilled water and mixed well.

Taken 10 c.c. of the unknown filtrate and the standard in separate test tubes and to each added 0.5 c.c. of saturated potassium per-sulphate followed by 2 c.c. of 3 N-Potassium Thiocyanate, Mixed by inversion and allowed to stand for half an hour and then read in the colorimeter within the same 30 minutes.

Calculation:- Haemoglobin (g) per 100 c.c. of blood =

$$\frac{\text{Reading of standard}}{\text{Reading of unknown}} \times 0.25 \times \frac{100}{0.5} \times \frac{1}{3.4}.$$

(e) Serum Total Protein:- Modified Micro-Kjeldahl Method:- Taken 1 c.c. of the blood serum in a 50 c.c. of volumetric flask and made up the volum with 0.9 % NaCl solution.

1 c.c. of this diluted mixture was taken in a large pyrex test tube (25 x 200m.m.) previously marked at 35 and 50 c.c. and to it, added 1 c.c. of 1:1 Sulphuric acid and a glass bead. Digested over a micro-burner till excess of water was evaporated, solution darkened and white fumes began to fill in the tube(in about 5 mimutes time). The digestion was continued for another three minutes, removed the tubes to cool for one minute, added 0.5 c.c. of saturated potassium per-sulphate solution drop by drop directly into the mixture and boiled again till the contents became clear. Cooled the tubes, diluted to 35 c.c. with distilled water and placed them in a beaker of cold water.

Now the standard was prepared. For this 3 c.c. of standard ammonium sulphate solution containing 0.05 mg of nitrogen per c.c. was taken in a 50 c.c. volumetric flask and to it added 1 c.c. of 1:1 sulphuric acid and 0.5 c.c. of saturated per-sulphate solution, diluted to 35 c.c. with distilled water and cooled * under tap.

Nesslerized the standard and the un-known by adding 1 c.c. of Nessler's reagent from a gruaduated cylinder, the contents being shaked during the process, and immediately added distilled water to make up the volume 50 c.c. Inserted a rubber stopper, mixed by inversion, allowed to stand for 10 minutes and then read in the colorimeter taking 10 c.c. at a time from each sample.

Calculation:- Percentage of protein (g) in serum =

$$\left\{ \left(\frac{\text{Reading of standard}}{\text{Reading of unknown}} \times 0.15 \times \frac{100}{V} \right) - \text{N.P.N} \right\} \times \frac{6.25}{1000},$$

Where, V is the actual volume of serum used.

(f) Non-protein Nitrogen:- Method of Koch & McMeekin (1924) modification of Folin and Wu method(1919):-

First, a protein free blood filtrate was prepared. For this 2 c.c. of oxalated whole blood was taken in a 50 cc. volumetric flask and was laked with 7 volumes (14 c.c.) of distilled water. Added 2 c.c. of 10% sodium tungstate solution and mixed well. Then, added slowly 2 c.c. of 2/3N sulphuric acid, inserted a rubber stopper and shaked the flask for facilitating complete precipitation, which was judged by the appearance of only a few bubbles as a result of shaking.

In cases, where colour of the coagulum did not change from red to dark brown, added drop~~s~~ by drop 10% sulphuric acid with shaking until there were practically no foaming and dark brown colour set in . Now the contents of the tube were filtered in a dry conical flask and a clear filtrate obtained.

For digestion, 5 c.c. of the filtrate were taken in a large dry pyrex test tube (25x200 m.m.) and digested as in case of total protein. Here, 1 to 2 drops of 30% H_2O_2 were added (not potassium persulphate as in case of total protein) to the solution for perfect decolourization of the same. Finally the solution was heated gently for 5 minutes more to remove excess of H_2O_2 , and then the tubes were cooled at room temperature. Added 35 c.c. of distilled water to the solution and placed them in a beaker of cold water.

The standard was also prepared as in case of total protein but without the addition of potassium per-sulphate. For Nesslerization and taking readings in the colorimeter, followed the same procedure as for total protein.

Calculation:- Percentage of N.P.N. (mg) in blood =

$$\frac{\text{Reading of standard}}{\text{Reading of un-known}} \times 0.15 \times \frac{100}{V}, \text{ where,}$$

V is the actual volume of blood taken for determination.

At the end of the experiment, blood of 4 Tharparkar calves upto one week age was also analysed for sugar, haemoglobin, total protein and N.P.N. in order to have an idea about the variation in these constituents with age.

THE DIGESTION TRIAL:- At the end of the experiment, a 10 days' digestion trial was conducted with 6 male calves (3 from each group) in order to determine if there was any appreciable difference in the digestibility of the food constituents in the two groups. The main object of this trial was to find out whether the difference in the digestibility of the two rations, if any, would contribute partially to the difference in the rate of growth and in the blood constituents of the two groups.

The trial was conducted in the metabolic shed of the local Livestock Research Station, where the calves were fed individually. A 5 days'preliminary period was allowed before actual collection of feces in order to get the calves accustomed to individual feeding and to the collection bags, which was naturally an unusual affair for them. Since the calves were fed with the original rations during the trial, no other preliminary period was necessary to correct for the change in the diet.

When the calves became accustomed to stall feeding and other local environments as evinced by food intake at previous levels, collection of feces was started. Feces was removed from the bags four times daily and collected in separate container. 24 hours' collection was weighed individually and representative samples taken out of this weighed excreta for various analyses. For the analysis of protein, about 15 g of the samples were stored daily in a wide mouthed bottle with 1 c.c. of concentrated H_2SO_4 as a preservative.

A 1/500th portion of the total excreta for a particular day was weighed separately and kept in hot air oven for other analyses. The estimation of protein was also made in the pooled samples of dried feces for the purpose of comparison.

Like other estimations, all analyses were made in duplicate and average of the two readings utilised for calculation. The results of these analyses have been shown in chapter IV on "RESULTS".

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CHAPTER IV

R E S U L T S

CHEMICAL COMPOSITION & NUTRITIVE VALUE OF FEEDS.

The chemical composition of the feeds used in this experiment has been listed in table XVII.

Table XVII.

Table showing the chemical composition of feeds (in percentage)

Feeds	Moisture	Crude protein	Crude fibre	Ether extract.	Total ash	N. F. E.
Wheat bran.	5.60	13.80	10.10	3.90	4.40	62.20
G.N.Cake	7.90	36.00	12.60	8.40	5.20	37.70
Gram	5.50	17.60	8.50	4.20	3.40	60.80
Grass hay (Spear)	8.00	5.60	35.80	1.30	12.30	37.00
Para grass (green)	72.0	2.20	11.05	0.40	2.12	12.23
Cow milk*	87.2	3.50	-	3.70	0.70	4.90

* Data from F.B. Morrison, Feeds & Feeding, 1959.

In order to determine the T.D.N. value of the feeds, the digestion coefficients for the different nutrients of the feeds given by Indian workers were utilised, failing which Morrison's data were taken into consideration. The digestion coefficients as given by the various workers and used in this experiments for computation of the rations have been detailed in table XVIII overleaf.

Table XVIII.

Table showing the digestion coefficeints of different nutrients (in percentage).

Feeds	Digestion coefficients				References
	Crude protein	Crude fibre	Ether extract	N.F.E.	
Weat bran	77.0	66.0	85.0	71.0	Bengalore
G.N.Cake	90.0	10.0	97.0	51.0	Bengalore
Gram	69.0	66.00	84.0	90.0	Lyallpur
Spear grass hay*	50.0	60.0	50.0	60.0	Morrison
Green Para grass	56.0	56.0	60.0	60.0	Morrison
Cow milk	94.0	-	97.0	98.0	Morrison

* Coefficients for a poor quality hay utilised.

From table XVII & XVIII, the amount of digestible nutrients present in each feed and also the T.D.N. value of the feeds were calculated. In computing the T.D.N. value of the feeds, the digestible ether extract was multiplied by 2.25 in each case. The digestible nutrient contents and the T.D.N. value of the feeds have been shown in table XIX.

Table XIX.

Table showing the digestible nutrient contents and the T.D.N. value of different feeds (in percentage).

Feeds	D.C.P.	Digesti- ble fibre	Digest. Ether Extract	Digest. N.F.E.	Total digestible nutrients.
Wheat bran	10.63	6.66	3.31	44.16	68.30
G.N.Cake	32.45	1.26	8.15	19.25	71.30
Gram	12.14	5.61	3.53	54.72	80.40
Spear grasshay	2.80	21.48	0.65	22.20	47.90
Green paragrass	1.20	6.15	0.24	7.34	15.28
Cow milk	3.29	-	3.59	4.80	16.17

From table XIX, the dry matter, digestible crude protein (D.C.P.) and the total digestible nutrients content of the two concentrate mixtures - control and experimental, and also those in Hay and Para grass per pound were calculated for ascertaining the intakes of these nutrients by the calves during the experimental period. These are listed in table XX.

Table XX.

Table showing the D.M.,D.C.P. & T.D.N. Contents of the rations (per lb).

Rations	D.M.	D.C.P.	T.D.N.
Control conc. mixture	0.87	0.173	0.68
Exptl. conc. mixture	0.87	0.131	0.68
Spear grass hay	0.92	0.028	0.48
Green para grass	0.28	0.012	0.15

On dry matter basis, the D.C.P. & T.D.N. content of the feeds per lb comes to :

	D.C.P.	T.D.N.
Control concentrate mixture	0.20	0.78
Exptl. concentrate mixture	0.15	0.78
Spear grass hay	0.03	0.53
Para grass (green)	0.04	0.55

OBSERVATIONS ON LIVEWEIGHT GAINS OF CALVES.

Mention has previously been made that the calves were weighed at intervals of every week. The consolidated account of the monthly increases in their liveweights are summerized in table XXI below.

Table XXI.

Table showing the monthly (4 weeks period) increase in the liveweight of the calves of the two groups(in lb).

Groups	Calf Nos.	Increase in liveweights Initial	April	May	June	July
Control	110/61	165.0	193.6	220.0	242.0	266.0
	114/61	138.6	167.2	193.6	217.8	237.6
	115/61	158.4	187.0	209.0	228.8	253.0
	116/61	114.4	138.6	158.4	180.4	202.4
	118/61	165.0	187.0	209.0	231.0	250.8
	124/61	90.2	110.0	132.0	*	*
Av.for group		138.6± 12.54	163.9± 12.26	187.0± 14.07	220.0± 10.89	241.8± 10.88
Exptl.	111/61	143.0	165.0	189.2	206.8	224.4
	112/61	114.4	134.2	154.0	171.6	187.0
	113/61	143.0	165.0	184.8	200.2	215.6
	117/61	123.2	145.2	162.8	180.4	195.8
	119/61	158.4	178.2	193.6	211.2	228.8
	120/61	149.6	169.4	184.8	198.0	220.0
Av.for group		138.6± 3.53	159.5± 6.57	178.2± 6.50	194.7± 6.31	211.9± 6.83

* Calf no. 124/61 removed from the lot in the month of June owing to its unfavourable reaction to the treatments.

From table XXI it would be seen that the calves in the experimental group gave lower weight gains in each month as compared to the calves in the control group, although the initial averages of the two groups were almost the same. Besides this, it is also noted that the calves within the same group differed considerably in the rate of increase in their body weights in different months, the lowest average increase in weight being in the month of June (0.78 lb per head in control group and 0.60 lb in the experimental group). The rate of gain of the two groups was also decreased in the month of May as compared to the gains in the month of April and July.

In order to examine whether these differences in the average liveweight increases of the two groups were significant or not, the data presented in table XXI were subjected to statistical analysis, in which the effect of the two treatments (levels of feeding) and the months on these differences were considered. The details of this analysis are presented in table XXII.

Table XXII.

Analysis of variance of the liveweights.

Sources of variation	D.F.	M.S.
Treatments ...	1	1679.75
Months ...	4	13496.89**
Interaction(Treatments x months)	4	650.62
Error ...	48	
Total ...	57	

** Highly significant at 1% level.

From the table above, it is found that neither the two levels of feeding nor the interaction, (treatment X months) had any significant effect on the increase in the body weights of the calves of the two groups. Also, it is noticed that the months had a very significant effect on the variations in the live-weight gains of the two groups in different months.

FOOD CONSUMPTION AND GROWTH RATE

The system of feeding the experimental animals and the method of recording their liveweight gains during the experimental period have already been described in chapter III on "Materials and Methods". The average amount of food and nutrient consumed and also the weight gained by each calf of the two groups during the experimental period are summarized in table XXIII.

Table XXIII.

Table showing the average food consumption and rate of gain of each calf during the experimental period (in pounds).

Particulars	April		May		June		July		August**	
	Control	Exptl.	Control	Exptl	Control*	Exptl	Control*	Exptl	Control	Experimental
Intakes of:										
Concentrate	80.0	80.0	85.0	86.0	90.0	90.0	98.0	100.0	105.0	110.0
Milk	8.0	8.0	-	-	-	-	-	-	-	-
Hay	24.0	25.0	22.0	20.0	25.0	25.0	28.0	25.0	30.0	26.0
Para	-	-	30.0	28.0	35.0	30.0	35.0	30.0	40.0	35.0
D.M.	93.40	94.30	102.0	101.0	111.10	109.70	120.80	118.40	130.15	129.40
D.C.P.	14.80	11.44	15.68	12.16	16.70	12.90	18.17	14.16	19.50	15.60
T.D.N.	67.22	67.70	72.50	72.30	78.45	77.70	85.00	84.50	91.80	92.93
Av. weight gain	25.30	20.90	23.10	18.70	22.00	16.50	22.00	17.60	24.40	19.80
Av.daily gain	0.90	0.75	0.83	0.67	0.80	0.60	0.80	0.63	0.98	0.80
Av.feed intake per lb gain	3.69	4.50	4.40	5.40	5.00	6.64	5.46	6.70	5.33	6.50

* Indicates the averages of 5 calves in control group.
** Indicates the averages of 3 calves in both groups.
Note:- The figures of April, May, June and July represent the averages for 28 days, while those of August are the averages of 25 days including 10 days digestion trial period.

From the above table, it would be seen that the increase in the body weight and thus the rate of growth in both the groups was lower in the month of May, June, and July. Also, it is seen that the growth rate was superior in case of the calves of control group to that of the experimental group. The feed intake per lb gain was also comparatively less for the calf of the control group. For example, the calf of the control group gained 25.30 lb in April, 23.10 lb in May and 22.0 lb in both June and July, the corresponding figures for the calf of the experimental group being, 20.90, 18.70, 16.50 and 17.60 lb for the above noted four months. Similarly, the feed intake per lb gain in control group was about 3.69 lb in April, 4.40 lb in May, 5.00 lb in June and 5.46 lb in July. The corresponding figures of feed intake per lb gain in experimental group were found to be 4.50 lb in April, 5.40 lb in May, 6.64 lb in June and 6.70 lb in July.

It is thus apparent that both the feed intake per lb gain and increase in liveweight in the two groups tended to improve in the month of July. This improved trend seen in July persisted for over three weeks of August, being the end of the experimental period. It is interesting to note that in 25 days of August, the calves of the control group gained on an average 24.40 lb and consumed a total of about 130.15 lb of dry matter(5.33 lb per pound liveweight gain), while the calves of the experimental group gained 19.80 lb and consumed 129.42 lb of dry

matter (6.50 lb per pound liveweight gain). The average rate of gain in the two groups in August was found to be 0.98 lb per head per day in control group and 0.80 lb per head per day in experimental group.

DIGESTIBILITY COEFFICIENTS OF FEEDS

In order to ascertain the difference between the digestibilities, if any, of the two rations - control and experimental, the digestion trial was conducted, the details of which have been furnished in chapter III. The average daily food and nutrient intakes and the average daily excretion in feces during the 10 days' digestion trial period have been presented in table XXIV.

Table XXIV.

Table showing the details of average daily food intake and excretion in feces during the digestion trial period in the two groups.

Groups	Average daily consumption (g)				Average daily excretion (g)	
	Conc.	Hay	Para	Dry Matter.	Fresh feces	Dry matter
Control	1953.30	930.20	929.0	2815.28	4652.20	937.50
Exptl.	1975.00	885.20	925.0	2791.45	3665.00	927.70

In order to determine the digestibility of the different food constituents in the two rations, the feces of both the groups were analysed to ascertain the amount of the food constituents excreted in the feces of each group. The details of the analysis of feces are furnished in table XXV overleaf.

Table XXV.

Table showing the details of analysis of composite sample of feces on dry matter basis(in percentage)

Groups	Dry matter	Crude protein	Crude fibre	Ether ext.	Total Ash	N.F.E.
Control	20.20	14.00	27.00	2.40	14.20	42.40
Exptl.	25.30	12.40	29.30	2.60	16.00	39.70

After the feces were analysed, calculations were made to determine the average daily excretion and percentage retention of the various nutrients in the two groups. It may be mentioned here that protein was analysed in both the composite, ~~xxxxxx~~ wet feces stored in referigerator with H_2SO_4 added to it and feces dried every day (for determination of D.M.). It was found that the two methods did not show any appreciable difference in the estimation of protein content of the feces - the wet samples showing only 1.12% higher result which is distinctly within the range of experimental error. The details of the observations on digestibility trial are summarized in table XXVI.

Table XXVI.

Table showing the details of data for estimation of digestibility coefficients.

Group	Details	D.M.	Crude protein	Crude fibre	Ether ext.	N.F.E.
Control	Av. daily: consumption (g)	2815.28	573.85	632.39	133.40	1256.50
	Excretion (g)	937.50	131.25	254.06	22.70	398.00
	Retention(g)	1877.78	442.60	368.33	110.70	858.50
	Digestibility (in %)	66.30	77.12	58.20	83.00	68.30
Exptl.	Av. daily: Consumption (g)	2791.45	405.57	598.17	98.16	1503.52
	Excretion(g)	927.70	115.03	271.80	24.30	368.11
	Retention(g)	1863.75	290.54	326.37	73.86	1135.41
	Digestibility (in %)	66.70	71.60	54.50	75.20	75.50

From the table above, it would be seen that the digestibility of crude protein, crude fibre and ether extract were better in the control group than in the experimental one, the figures being respectively 77.12%, 58.20% and 83.0% in the former and 71.60%, 54.50% and 75.20% in the latter group. The higher digestibilities of these nutrients in the control group fits in well with the generally observed beneficial effect of higher levels of protein on the digestion coefficient of these nutrients.

Since only a small number of animals were included in this trial, no attempt has been made to interprette the results statistically.

OBSERVATIONS ON THE ANALYSIS OF BLOOD CONSTITUENTS

It has been mentioned in chapter III that the blood samples from each calf were analysed at fortnight intervals for serum calcium, inorganic phosphorus, sugar, haemoglobin, serum protein and N.P.N. The results of analysis of these constituents in the blood of individual animals have been presented in tables XXVII, XXVIII, XXIX, XXX, XXXI and XXXII and the average values of these for the groups in a consolidated form are given in table XXXIII.

In order to find out the effect of feeds and of the months on the variations in these constituents, the data for these blood constituents for each month were subjected to statistical analysis. In this connection, it is essential to mention here that since these data were obtained in terms of percentages, their scale of measurement was first changed to angles corresponding to their percentages by way of a "Transformation" before analysis, Angle being equal to Arcsin $\sqrt{\text{percentage}}$, as given by C.I.Bliss(1937) and presented in table 11.12.1 of "Statistical Methods" by G.W. Snedecor (1956), and these changed values were utilised for statistical analysis. Back transformations were made to estimate the standard errors in each case.

The results of statistical analysis of the variance of these blood constituents are presented in table XXXIV.

For a comparative study, the blood samples from four Tharparkar calves upto one week age were also analysed for sugar, H_b, total protein and N.P.N. The results of this analysis have been presented in table XXXV.

Table XXVII.

Analysis of blood for Serum Calcium at fortnight intervals

Fortnight intervals	Control Group						Experimental Group					
	A_1	A_2^*	A_3	A_4	A_5^*	A_6	A_1	A_2^*	A_3^*	A_4	A_5	A_6
Initial	12.0	10.0	12.5	11.5	10.5	11.0	11.5	10.5	11.0	10.5	12.5	11.5
First	12.5	10.0	12.0	11.5	11.0	12.0	11.5	10.5	11.0	11.0	12.5	12.0
Second	12.5	10.5	12.5	11.5	11.0	12.2	11.5	10.5	11.0	11.5	12.0	12.0
Third	13.0	10.5	12.5	11.5	11.0	12.2	11.5	10.5	11.0	11.5	12.0	12.5
Fourth	13.0	11.5	13.0	12.0	11.8	-	12.5	11.2	11.5	12.0	12.0	12.5
Fifth	13.2	11.5	13.0	12.5	12.0	-	12.5	11.5	11.5	12.5	12.0	12.5
Sixth	13.5	11.0	12.5	12.5	11.5	-	12.0	11.0	11.5	12.0	11.5	12.0
Seventh	13.0	11.0	12.0	12.2	11.5	-	12.0	10.5	11.5	12.0	12.0	12.0
Eirghth	13.0	10.5	12.0	12.0	11.0	-	12.0	10.5	11.0	11.5	12.0	11.5

* Indicates female calves .

Note:- A_1, A_2 etc. indicate the number of calves in each group.

2. The values are presented in terms of mg of calcium in 100 c.c. of serum.

3. The animal number 6 (124/61) removed from the lot only after the third fortnight of blood analysis owing to its individual in-disposition.

Table XXVIII.

Analysis of blood for Serum Inorganic Phosphorus at fortnight intervals

Fortnight intervals	Control Group						Experimental Group					
	A_1	A_2	A_3	A_4	A_5	A_6	A_1	A_2	A_3	A_4	A_5	A_6
Initial	6.2	5.2	6.2	6.2	5.6	6.0	6.4	4.9	5.8	6.0	6.2	6.2
First	6.5	5.6	6.4	6.2	5.8	6.2	6.6	5.2	6.0	6.4	6.2	6.5
Second	6.4	5.8	6.5	6.2	6.0	6.0	6.4	5.8	6.4	6.0	6.5	6.2
Third	6.4	6.0	6.5	6.2	5.9	6.3	6.5	6.0	6.2	6.4	6.4	6.2
Fourth	6.4	6.0	6.5	6.4	6.0	-	6.6	6.3	6.0	6.5	6.5	6.4
Fifth	6.7	5.8	6.4	6.4	6.2	-	6.9	6.2	6.2	6.7	6.5	6.2
Sixth	6.4	5.5	6.2	6.0	5.8	-	6.6	6.0	6.0	6.4	6.4	6.2
Seventh	6.4	5.1	6.0	5.8	5.6	-	6.5	5.8	5.8	6.0	6.0	6.6
Eighth	5.8	5.4	6.2	5.6	5.5	-	6.8	5.2	6.0	6.2	6.0	6.0

Note:- The values are in terms of mg percent of serum.

Table XXX.

Analysis of blood for Haemoglobin at fortnight intervals*

Fortnight intervals	Control Group						Experimental Group					
	A_1	A_2	A_3	A_4	A_5	A_6	A_1	A_2	A_3	A_4	A_5	A_6
Initial	14.60	10.56	12.80	12.20	11.20	12.50	12.60	10.60	11.92	12.80	13.76	12.90
First	14.40	10.48	12.65	12.05	10.92	12.45	12.65	10.48	11.73	12.20	13.56	12.56
Second	14.30	10.50	12.48	12.25	11.02	12.48	12.50	10.48	11.50	12.35	13.46	12.50
Third	14.30	10.20	12.36	12.05	11.02	12.27	12.35	11.30	11.33	12.20	13.33	12.20
Fourth	13.88	10.16	12.26	11.90	10.87	-	12.26	10.12	11.16	12.13	12.88	12.02
Fifth	13.72	10.10	12.00	12.00	10.72	-	12.17	10.03	10.99	12.11	12.60	11.99
Sixth	14.37	10.48	12.93	12.66	11.20	-	12.55	10.34	11.27	12.27	12.86	12.35
Seventh	14.60	10.96	13.23	12.75	11.68	-	12.75	10.48	11.38	12.50	13.03	12.50
Eighth	14.70	11.22	13.45	12.98	12.20	-	12.86	10.62	11.67	12.50	13.09	12.57

* The values are presented in terms of g of Hb per 100 c.c. of blood.

Table XXIX.

Analysis of blood for sugar at fortnight intervals*.

Fortnights	Control Group						Experimental Group					
	A_1	A_2	A_3	A_4	A_5	A_6	A_1	A_2	A_3	A_4	A_5	A_6
Initial	79.0	92.5	88.0	92.5	79.0	83.5	88.0	88.0	79.0	92.5	79.0	83.5
First	79.0	88.0	88.0	88.0	74.5	79.0	88.0	83.5	79.0	88.0	79.0	83.5
Second	74.5	88.0	83.5	88.0	74.5	79.0	83.5	83.5	74.5	88.0	74.5	79.0
Third	74.5	83.5	83.5	83.5	74.5	74.5	83.5	79.0	74.5	83.5	74.5	74.5
Fourth	70.0	79.0	79.0	79.0	70.0	-	79.0	74.5	70.0	79.0	70.0	74.5
Fifth	65.5	74.5	74.5	74.5	65.5	-	74.5	70.0	65.5	74.5	70.0	70.0
Sixth	65.5	70.0	70.0	74.5	61.0	-	70.0	70.0	65.5	70.0	65.5	70.0
Seventh	61.0	65.5	65.5	70.0	61.0	-	70.0	65.5	61.0	65.5	65.5	65.5
Eighth	56.5	61.0	65.0	65.0	61.0	-	65.5	61.0	61.0	61.0	65.5	65.5

* The values are presented in terms of mg of sugar per 100 c.c. of blood.

Table XXXI.

Analysis of blood for serum total protein at fortnight intervals*

Fortnight intervals	Control Group						Experimental Group					
	A_1	A_2	A_3	A_4	A_5	A_6	A_1	A_2	A_3	A_4	A_5	A_6
Initial	7.30	5.75	6.16	6.30	6.42	6.58	6.90	6.71	6.66	6.60	6.60	6.45
First	7.03	5.68	6.10	6.15	6.40	6.50	6.86	6.45	6.60	6.55	6.52	6.45
Second	6.68	5.75	6.00	6.10	6.45	6.45	6.85	6.38	6.55	6.50	6.50	6.45
Third	6.70	5.85	5.80	6.00	6.50	6.45	6.75	5.95	6.45	6.40	6.45	6.50
Fourth	6.65	5.90	5.80	6.00	6.45	-	6.80	5.80	6.40	6.35	6.40	6.45
Fifth	6.60	5.98	5.85	6.60	6.56	-	6.68	5.85	6.40	6.00	6.35	6.50
Sixth	6.75	6.00	5.95	6.25	6.50	-	6.70	5.85	6.35	5.75	6.40	6.45
Seventh	6.90	6.35	6.00	6.40	6.55	-	6.75	5.90	6.45	5.80	6.50	6.55
Eighth	7.00	6.45	6.25	6.40	6.50	-	6.90	6.00	6.40	5.85	6.45	6.60

* The values are presented in terms of g of total protein in 100 c.c. of blood serum.

Table XXXII.

Analysis of blood for non-protein nitrogen at fortnight intervals.*

Fortnight intervals	Control Group						Experimental Group					
	A_1	A_2	A_3	A_4	A_5	A_6	A_1	A_2	A_3	A_4	A_5	A_6
Initial	32.14	38.68	35.32	35.35	38.45	36.71	38.36	35.48	34.45	35.48	34.44	38.30
First	34.12	38.90	36.36	37.30	38.90	37.50	38.56	37.50	35.65	36.71	35.65	38.60
Second	35.65	38.90	37.50	37.50	38.66	38.93	39.00	38.30	36.30	37.10	36.71	38.60
Third	36.00	36.60	38.30	38.13	38.00	38.56	39.90	39.13	37.56	38.30	37.10	38.60
Fourth	37.10	36.45	38.72	38.90	38.45	-	38.14	39.56	36.45	39.13	38.30	38.90
Fifth	37.50	36.00	38.13	38.78	36.90	-	39.38	39.78	37.18	40.00	39.56	36.38
Sixth	37.50	36.45	38.56	38.00	36.45	-	40.38	40.00	36.90	40.45	38.66	38.38
Seventh	36.71	36.56	38.30	38.72	36.56	-	38.67	40.00	36.45	38.00	39.45	36.90
Eighth	35.30	38.30	36.50	37.50	37.72	-	38.00	38.72	35.78	36.56	38.80	36.45

* The values are presented in terms of mg of N.P.N. in 100 c.c. of blood.

Table XXXIII.

Table showing the average values of the different blood constituents in the two groups.

Fortnights	Calcium mg%		Inorganic phosphorus mg%		Sugar mg%		Haemoglobin g%		Total protein g%		N.P.N. mg%	
	Contl.	Exptl.	Contl.	Eptl	Cont.	Exptl	Contl	Exptl	Cont.	Expt	Contl.	Exptl.
Initial	11.25	11.25	5.90	5.90	85.75	85.00	12.31	12.43	6.42	6.65	36.10	36.08
First	11.50	11.40	6.12	6.15	82.75	83.60	12.16	12.19	6.31	6.57	37.18	37.11
Second	11.71	11.41	6.15	6.22	81.25	80.50	12.17	12.13	6.24	6.54	37.86	37.70
Third	11.79	11.50	6.22	6.30	79.00	78.16	12.03	11.95	6.22	6.42	37.60	38.43
Fourth	12.21	11.95	6.25	6.40	75.40	74.50	11.90	11.76	6.16	6.37	37.92	38.40
Fifth	12.42	12.10	6.25	6.44	70.90	70.75	11.76	11.65	6.32	6.30	37.46	38.70
Sixth	11.79	11.66	6.0	6.27	68.20	68.50	12.33	11.94	6.29	6.25	37.40	39.13
Seventh	11.90	11.60	5.80	6.20	64.60	65.50	12.65	12.10	6.45	6.33	37.37	38.25
Eighth	11.70	11.40	5.64	6.20	61.80	63.25	12.91	12.22	6.52	6.36	37.96	37.39
Average	11.80± 0.34	11.58± 0.28	6.04± 0.23	6.27± 0.16	74.41± 8.46	74.42± 7.90	12.25± 0.35	12.04± 0.24	6.32± 0.12	6.42± 0.13	37.43± 0.36	37.91± 0.94

Table XXXIV.

Table showing the results of analysis of variance of the different blood constituents.

Sources of variation	Values of M.S. for different blood constituents					
	Calcium	Phosphorus	Sugar	Hb	Total protein	N.P.N.
Treatments	0.5547	0.0866	37.6028	0.5323	0.3526	2.8836
Months	0.7763	0.8106**	459.9848*	0.6504	0.1425	1.2155
Interaction (Months x treatments)	0.0552	0.3238	11.3589	0.1965	0.1475	0.3767
Error	0.4573	0.2696	16.9546	0.1811	0.1671	0.8611
Total:						

* Significant at 1% level
** Significant at 5% level.

From the above analysis of variance, it is revealed that neither the two levels of feeding (treatments) nor the interaction (treatments x months) had any significant effect on the variation of any of the blood constituents, but there was a significant effect of months on the values of blood sugar and phosphorus in the two groups.

Referring back to table XXXIII, it will be seen that the values of calcium and phosphorus tended to increase, that of haemoglobin tended to decrease while those of total protein and N.P.N. tended to remain more or less constant during the period of the fifth fortnight of blood analysis. The values of sugar, on the other hand, showed a continuous decreasing trend throughout the experimental period.

The trends of the changes in the various blood constituents have been graphically represented in figures from 2 to 7.

Table XXXV.

Table showing the levels of ~~calcium, phosphorus~~ Total protein, N.P.N., sugar and haemoglobin in the blood of calves upto one week age* .

No. of observations	Sugar mg%	Haemoglobin g%	Total protein g%	N.P.N. mg%
1	101.5	14.50	6.52	36.0
2	97.5	13.45	6.82	35.80
3	101.5	12.25	6.72	36.15
4	97.5	12.92	6.36	36.53
Average	99.25	13.28	6.62	36.12

* The levels of calcium and inorganic phosphorus not determined because of rather larger volume of blood required for analysis of these two constituents.

From the above table, it is evident that the blood of one week old calves of this breed contained higher levels sugar, haemoglobin and total protein as compared to the blood of the older calves of our experiment, the values for the former being on an average, 99.25 mg of sugar, & 13.28 g of haemoglobin per 100 c.c. of blood and 6.62 g of total protein per 100 c.c. of serum. The level of N.P.N. was found to be more or less similar to those in case of the older calves of this breed.

*****

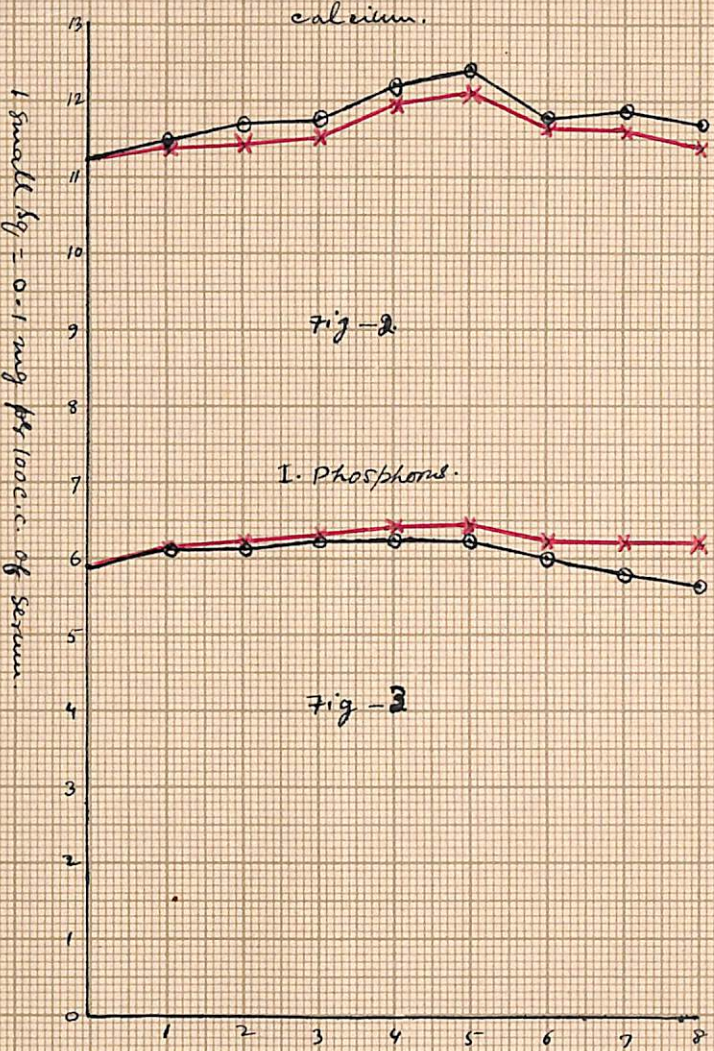
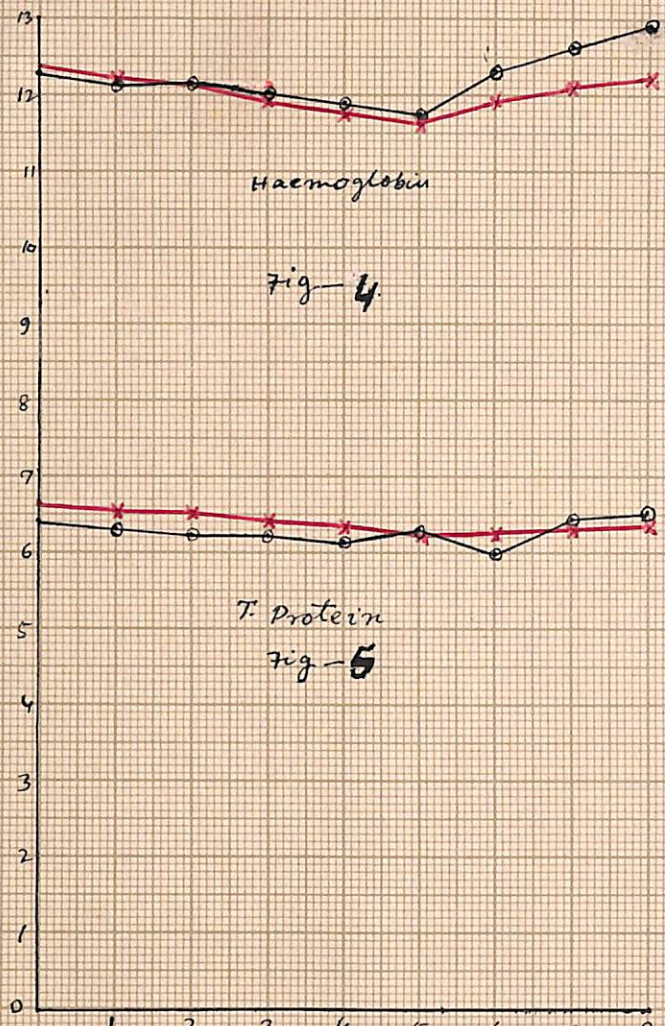


Fig – 2.

I. Phosphorus.

Fig – 3

— control group.
— exptl. group.



Haemoglobin

Fig — 4

T. Protein

Fig — 5

— control group

— exptl. group.

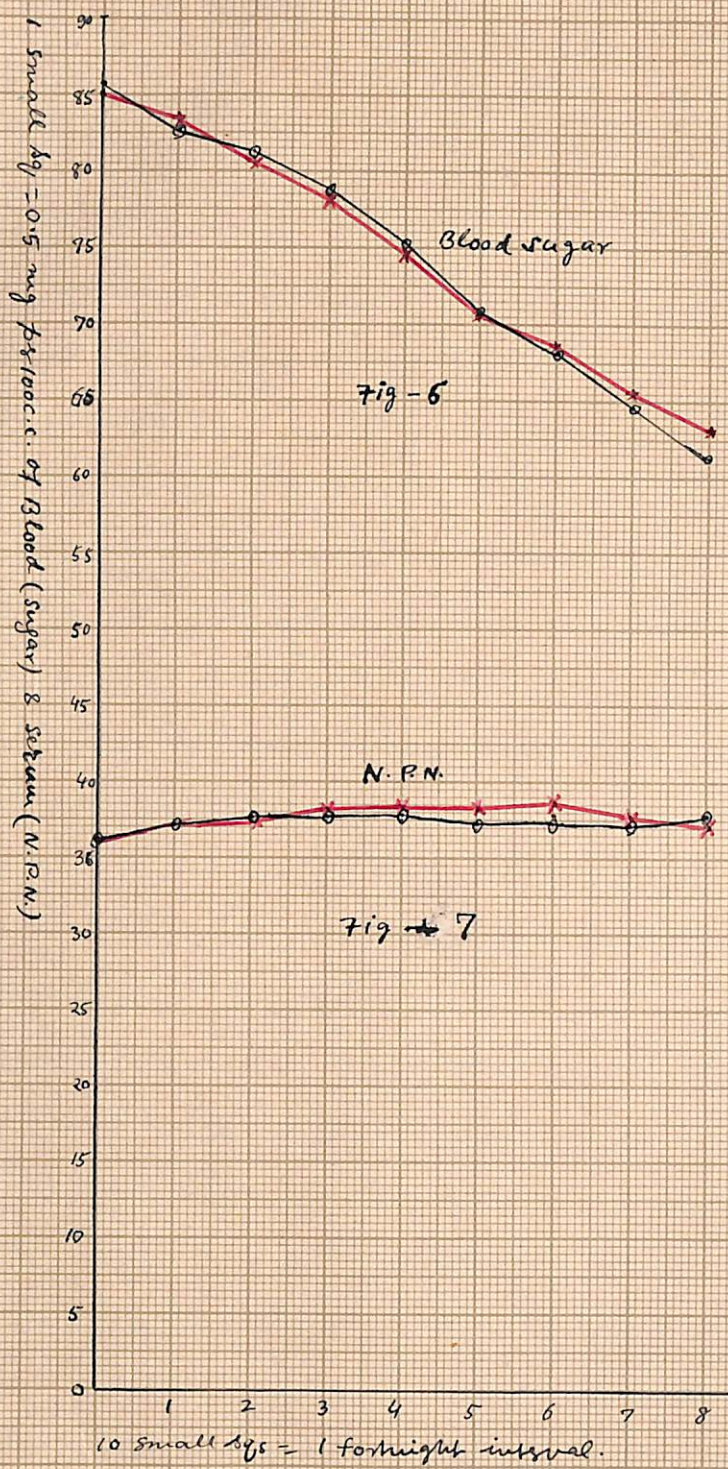

1 small sq = 0·5 mg per 100 c.c. of Blood (sugar) & serum (N.P.N.)
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
Blood sugar
N.P.N.
1
2
3
4
5
6
7
8
10 small sqs = 1 fortnight interval.
Exptl group
Control group

Fig - 6

Fig - 7

CHAPTER V.

D I S C U S S I O N

GROWTH RATE AND FOOD UTILISATION

It would be seen from table XXI and XXIII that the calves of both the groups exhibited improved rates of growth in the months of April and August. The calves of the control group gained on an average 0.90 lb per day in April and 0.98 lb per day in August. The average daily gain of the calves of experimental group was 0.75 lb in April and 0.80 lb in August. The lowest average increase in liveweights of calves of control group was recorded in the months of June and July. So was the case with the calves of the experimental group, but they showed slight improvement in the month of July over that of June. The highest rate of growth in both the groups was obtained during the month of August.

From table XXIII, it is also evident that the calves consumed relatively lesser amount of food during the months of May, June and July in view of their increased liveweights in these months. Although, the calves of the control group each consumed about 4.40 lb of food in May, 5.00 lb in June and 5.46 lb in July, the corresponding figures for the calves of the experimental group being 5.40, 6.64, and 6.70 lb respectively, it is to be remembered

that a portion of the gradual increase in these food intakes (per lb gain) with the age of the calves in these months was due to the proportionately higher requirements for their maintenance.

It is thus brought up clearly that the calves of both the groups, in these three months, did not consumed the food in quantities usually required for the calves of this age and body weight. Here it is essential to mention that during the experimental feeding of the calves, it was found that they did not consumed all the concentrate mixtures nor all the roughages. Consequently, there were considerable "food refusals" particularly of hay and to some extent of grains also. Now, on learning that both the concentrates and roughages were supplied in accordance with their increased body weights throughout the experimental period, it is conceivable to think that the animals were consuming their maximum amount of concentrates and roughages all along the duration of the experiment,and thus it is safer to infer that the rate of growth obtained in this experiment was the maximum expected of calves between the age of 5 to 8 months at 17.5 % protein in the concentrate mixture during the particular period of the year. Whether higher growth rates could have been obtained on still higher levels of protein intake, was not in the per view of the present experiment.

The main reason of the calves refusing the food

during the above mentioned three months appeared to be the increased atmospheric temperatures of May and June and increased humadity with high temperature of July. Mullick and Kehar (1952) have also reported differences in the feed intakes of normal Indian cattle under different environmental conditions leading to a significant variation in the body weights of the animals both between the months and between the animals. Earlier, Ragsdale, Brody, Thompson and Worstell (1948) have also reported, "Physiological wisdom dictates the reduction of feed consumption with increasing temperature so as to reduce the heat production associated with feeding, which the animal can not dissipate, and this is what happens". Brobeck (1948) also stated, "food intake appears to be controlled as if it were a mechanism for temperature regulation".

In view of all these facts, the average rate of growth of the calves in the control group of our experiment for the experimental period was found to be 0.86 lb per head per day and that of the calves in the experimental group, it was 0.69 lb per head per day. Morrison (1936) has recorded the rate of gain of calves of various breeds from birth to two years of age based on data from several experiment stations in the U.S.A. These data clearly show that the average rate of gain of heifers of 4 to 10 months age was 1.82 lb per head daily for the Holsteins, 1.42 lb for

the Jerseys, 1.38 lb for Guernseys and 1.45 lb for the Ayrshire heifers. Raju (1953) has reported that the average rate of gain of Kangyam calves between 4 to 6 months of age was 0.85 lb per head per day. As early as 1934, Sayer obtained an average rate of gain in Sahiwal heifers placed on special and ordinary Farm diet to be 1.21 and 1.03 lb respectively. On special feeding regime, Roy (1961) obtained a growth rate of 1.7 lb per head daily in Hariana calves, while Yamdagni (1962) obtained a rate as high as 1.9 lb per head daily in the same breed.

Although, the systems and levels of feeding the calves in the experiments of Roy and Yamdagni are not known, data collected by Morrison on cost of raising dairy heifers reveal that the heifers upto 2 years or to the age of first calving at most of the experiment stations in the U.S.A. are usually raised on whole milk, skim milk, good quality concentrate and pasture. At some stations nurse cows are also used. In the experiment of Sayer (1934), the special diet for Sahiwal heifers contained an extra amount of milk and some change in the usual Farm concentrate mixture.

In the present study, the milk was completely withdrawn at the age of 5 months of the calves and the hay supplied was of poor quality. The concentrate mixture fed to the control group contained about 17.3 % and that fed to the experimental group contained 13.1%

protein (D.C.P.). Moreover, the T.D.N. contained ~~of~~ in the two mixtures was only 68%. The example rations for dairy cows and heifers given by Morrison (1957) suggest that when no legume roughage is fed to the heifers, the concentrate mixture should contain 17 to 17.5% of D.P. and 72 to 74% of T.D.N. It must be remembered that the computationsof these rations suggested by Morrison have been based on supplements containing 34 to 44% protein guarantee such as,linseed meal (34% protein grade), cotton seed meal (41% protein grade) and soybean oil meal (44% protein grade), all of which contain a protein of high biological value.

The efficiency of food utilisation and that of gain in terms of lb of T.D.N. required per lb gain were found to be better in the control group than the experimental one throughout the experimental period. Reffering back to table XXIII, it will be seen that the average amount of T.D.N. utilised per lb gain for the experimental period in control group was 3.3%lb and that for the experimental group, it was 4.22 lb. The determination of digestion coefficients of the two rations (table XXVI) has shown that the digestibilities of protein,fibre and also that of the ether extract were much improved in the control group over those in experimental group. Now,the control ration having 25% extra D.C.P. per lb than the experimental ration, the differences in the digestibilities of these nutrients in the two groups must have been

due to the higher protein content of the control ration. No apparent explanation seems to be available for the present as regards better utilisation of N.F.E. in the experimental group. The generally observed beneficial effects of levels of protein on the digestibilities of all these food constituents of a ration are supported by the recent observations on this phenomenon by Brown et al. (1958), Everette (Jr.) et al.(1958) and Kesler and Wilson (1959) in case of calves. Jemsen etal (1957) and Rutledge et al.(1961) have reported similar observations in case of pigs.

VARIATIONS IN DIFFERENT BLOOD CONSTITUENTS

Serum Calcium:- The value of calcium in the control group varried between 11.25 and 12.24 mg with an average of 11.80 ± 0.34 mg per 100 c.c. of the serum. In the experimental group, it ranged between 11.25 and 12.10 mg and the mean value was 11.58 ± 0.28 mg per 100 c.c. of serum. The lowest values in both the groups were obtained in the month of April and the highest value in the month of June.

Statistical analysis revealed that these variations in the values of calcium in the two groups were not significant so far as the effects of feeds and those of the months were concerned. This nearly constant serum calcium level in both the groups is understandable, because the rate of growth of the two groups was more or

less uniform during the experimental period.

Mullick and Pal (1943) reported a value of 13.4 to 13.5 mg of calcium per 100 c.c. of serum in Hariana calves between 6 to 12 months age. The average value of calcium in adult Hariana cattle was reported to be 11.4 mg per 100 c.c. of serum for cows and 11.2 mg per 100 c.c. of serum for bullocks. They also reported a value of 11.1 mg in case of Dhani bullocks. All these findings show that growing calves usually contained a higher level of calcium as compared to the adults in their blood serum. Thus, the calcium content of blood of calves in the present study was within the limits of those reported by Mullick and Pal. Information regarding the calcium level of either growing or adult Tharparkar cattle does not seem to be available. Anderson et al. (1930), and Rusoff and Frye (Jr.) (1951) have also reported a higher value of calcium in growing calves as compared to the adults.

Serum Inorganic Phosphorus:- The mean value of inorganic phosphorus in the control group was found to be 6.04 ± 0.23 mg per 100 c.c. of serum with a range of 5.64 to 6.25 mg. In the experimental group, the mean value was 6.27 ± 0.25 mg per 100 c.c. of serum with a range of 5.90 to 6.44 mg. In this case as well, the differences in the two groups were not statistically significant, nor the effects of feeds and of the months

on the variation in their values were significant.

Mullick and Pal (1943) reported an average value of serum inorganic phosphours in case of 0-6 months old Hariana calves to be 6.70 mg and that for 6 to 12 months old calves, 5.55 mg per 100 c.c. of blood. Rusoff and Frye (Jr.) (1951) reported a value of 7.58 ± 0.08 mg per 100 c.c. of serum in case of 5 months old Red Sindhi- Jersey female calves. Thus, the present finding for the Tharparkar calves(5 to 9 months old) falls well within the limits of the values reported by the above mentioned workers.

It is interesting to note from table XXXIII that the value of Phosphorus in both the groups rose as the level of calcium rose, and decreased as the level of calcium decreased. These fluctuations in the two constituents were more sharply defined during the months of May,June and first half of July,in which the levels of both of these increased simultaneously and then gradually fell in the same order. Marsh and Swingle (1955) have also reported an increase in the level of these two constituents in the month of July in case of sheep. Pal et al.(1945) in normal adult Hariana cows and Raghavan and Mullick (1962) in buffaloe bulls have also reported an increase in the level of calcium in summer months. As regards phosphorus, however,the two workers have reported an irregular relationship of phosphorus with air temperature.

Blood Sugar:- The mean value of blood Sugar in the control group was 74.41 ± 8.46 mg per 100 c.c. of blood with a range of 85.75 mg in April (beginning of the experimental period) and 61.80 mg in the month of August (end of the experimental period). In case of experimental group the mean value was 74.42 ± 7.90 mg per 100 c.c. of blood with a range of 85.0 mg in April and 63.25 mg in August. The average blood sugar level in the calves upto one week age was found to be 99.25 mg per 100 c.c. of blood. Mullick and Pal (1943) reported a value of 105.90 mg for 0 - 6 months old Hariana calves and 97.65 mg per 100 c.c. of blood of 6 to 12 months old calves. McCandless and Dye (1950) have reported that in calves, the blood sugar level was 97.0 mg per 100 c.c. at 10 days' of life, which gradually decreased to 61 mg per 100 c.c. at the age of 6 months (175 days). Thus, the values ~~wf~~ obtained in the present study were within the range of those obtained by these workers in different breeds of calves.

The data presented in table XXIX and XXXIII on comparison with those presented in table XXXV indicate that the level of blood sugar fell, though gradually, with the advancement of age. Mullick and Pal (1943) ~~w~~ in Hariana cattle and McCandless and Dye (1950) in different species of domestic as well as wild ruminants have reported similar observations. The latter workers

as a result of their extensive series of experiments have come to the conclusion that blood sugar level is inversely related to size and functional development of the rumen. This relationship seems to hold good also in case of blood sugar level of calves used in the present study.

Haemoglobin:- The mean haemoglobin value for the control group was found to be 12.25 ± 0.35 g per 100 c.c. of blood with a range of 11.76 g to 12.91 g . In case of experimental group, the mean Hb value was 12.04 ± 0.24 g per 100 c.c. of blood with a range of 11.65 g to 12.43 g. In the calves upto one week age, the average value of Hb was found to be 13.28 g per 100 c.c. of blood.

Mullick and Pal (1943) reported a value of 15.5 g to 16.0 g for calves between 0 - 6 months age, the average being 15.75 g per 100 c.c. of blood. For calves between 6 to 12 months age , they reported a value of 13.1 to 14.0 g with an average of 13.55 g per 100 c.c. of blood. Rusoff and Frye (Jr.) (1951) reported an average value of 10.26 ± 0.06 g per 100 c.c. of blood in case of 5 months old Red Sindhi-Jersey female calves. Thus, the values obtained in the present study were lower than those reported by Mullick and Pal in either case and higher than those reported by Rusoff and Frye(Jr.)(1951). These little differences in value of Hb in different breeds of cattle may be attributed to the breed charasteristics.

The data presented in table XXX and XXXIII suggest that the values of Hb in the experimental animals decreased during hotter months (May - July). Manresa et al.(1940) in case of Phillipine cattle, Pal et al.(1943) in Indian dairy cows, Mukherjee and Bhattacharya (1952) in bulls and Raghavan and Mullick (1962) in buffaloe bulls have reported similar results. It is interesting to observe that the value of Hb tended to rise again in the month of August, during which time rains had started and consequently the local environment had become comparatively cooler.

Total Protein:- The average total protein content in case of control group was found to be 6.32± 0.12 g per 100 c.c. of serum with a range of 6.16 g to 6.52 g. In case of experimental group, the average value of total protein was found to be 6.42± 0.24 g per 100 cc. of serum with a range of 6.25 to 6.65 g . The average value for this constituent in the calves upto one week age was obtained at 6.62 g per 100 c.c. of serum.

Sufficient data are not available regarding the normal levels and causes of variation, if any, in the value of this constituent in case of growing calves, although, plenty of data exist for adult animal. Thus, Kehar and Murthy (1945,1951 & 1952) have reported a value of 8.61,7.46± 0.09 and 6.79± 0.25 g per 100 c.c. of serum for bullocks of Hariana,buffaloe and kumaoni

breeds respectively. Sen and Roy (1933) reported a value of 6.0621 to 9.0470 g for Hill bulls, Kehar (1940) reported 9.34 g in normal Indian cows, and Pal et al. (1945) reported a value of 7.3 to 7.4 g per 100 c.c. of serum in normal adult Hariana cows.

In the light of these available information, the comparatively lower values obtained by us for Tharparkar calves may be due to the younger age of the experimental animals and may perhaps be a normal physiological phenomenon.

Non-Protein Nitrogen:- The mean N.P.N. content in the blood of control group was found to be 37.43 ± 0.36 mg per 100 c.c. with a range of 36.10 to 37.96 mg. In the experimental group the value was found to be 37.91 ± 0.94 mg per 100 c.c. with a range 36.08 to 39.13 mg. The value obtained in case of calves upto one week age was 36.12 mg per 100 c.c. of blood.

Literatures, in this case also, are very limited to show the concentration of N.P.N. in the blood of growing calves, although, Pal et al.(1945) have reported a value of 35.6 mg per 100 c.c. of blood in April and 36.5 mg in May and June and 37.7 mg in July in adult Hariana cows. Raghavan and Mullick (1962) have reported a value ranging from 41.22 ± 1.25 mg at low temp^{r}. to 43.22 ± 3.0 mg per 100 c.c. at higher temperatures in case of buffaloe bulls. The trend of variation in its value in the present study seems to be in agreement with that observed by the above noted workers.

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CHAPTER VI

SUMMARY AND CONCLUSION

Studies on 12 Tharparkar calves of 5 months age divided into two groups - Control and Experimental, were made to study their growth rate and changes in some of the important blood constituents on two rations containing an equal amount of energy and two different levels of protein (17.3% for the control and 13.1% for the experimental group). The experiment was continued over a period of about 5 months during which the increase in the body weights of the calves and fortnightly variation in the levels of different blood constituents were ascertained. The daily intake of food was accurately measured and efficiency of food utilisation and gain worked out.

The blood constituents under study were serum calcium, inorganic phosphorus, sugar, haemoglobin, serum protein and non-protein nitrogen. For the purpose of comparison, the blood samples from four Tharparkar calves upto one week age were also analysed for sugar, haemoglobin, serum protein and N.P.N.

At the end of the experimental period, a digestion trial was conducted on six animals (three from each group) over a ten days' collection period.

An analysis of the data on growth rate showed that the differences in growth rates of the two groups on two levels of protein feeding were not statistically significant. Each calf of the control group, on an average, gained at the rate of 0.90 lb per day in the first month (28 days in April), 0.83 lb per day in the second month (28 days in May) and 0.80 lb in the third and fourth months (28 days in both June and July). The corresponding figures for the calf of the experimental group were 0.75 lb in April, 0.67 lb in May, 0.60 lb in June and 0.63 lb in July. The highest growth rate in both the groups was obtained in the month of August (for 25 days only), where the calf of the control group gained at the rate of 0.98 lb per day and that of the experimental group at the rate of 0.80 lb per day.

The feed intakes (D.M.) per pound gain by the calf of control group were 3.69 lb in the first month, 4.40 lb in the second, 5.06 lb in the third, 5.46 lb in the fourth and 5.33 lb in the last month i.e. August. The corresponding figures for the calf of the experimental group were 4.50, 5.40, 6.64, 6.70, and 6.50 lb.

The digestion trial revealed that there was better utilisation of protein, fibre and ether extract of the ration in the control group than the experimental one. It was ascribed to higher level of protein in the control ration.

The studies on the important constituents of blood revealed that there was no significant difference in the average value of any of them in the two groups during the experimental period. The average values of these constituents for the experimental period in the two groups and those of calves upto one week age were found to be as follows:-

Group	Ca.	Inorganic phosphorus	Sugar	Hb.	Total protein	N.P.N.
	mg%	mg%	mg%	g%	g%	mg%
Control	11.80± 0.34	6.04± 0.23	74.41± 8.46	12.25± 0.35	6.32± 0.12	37.43± 0.36
Exptl.	11.58± 0.28	6.27± 0.16	74.42± 7.90	12.04± 0.24	6.42± 0.13	37.91± 0.94
1 week old calf	-	-	99.25	13.28	6.62	36.12

The levels of calcium and phosphorus in the two groups tended to increase in summer months. The levels of sugar and haemoglobin decreased with age and those of total protein and N.P.N. did not appear to show any appreciable variation with these factors.

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