STUDIES ON THE EFFECT OF LOW-PROTEIN & LOW-ENERGY ON THE GROWTH OF THARPARKAR CALVES

Thesis

Submitted to the

MAGADH UNIVERSITY

IN PARTIAL FULFILMENT OF THE REQUIREMENT
FOR THE DEGREE OF

MASTER OF SCIENCE (A. H.)

IN ANIMAL NUTRITION.

BY

T.V.L. Satyanarayana Gupta
B. V. Sc.,

Bihar Veterinary College
PATNA

1967.

STUDIES ON THE EFFECT OF LOW-PROTEIN & LOW-ENERGY ON THE GROWTH OF THARPARKAR CALVES

Thesis

Submitted to the

MAGADH UNIVERSITY

IN PARTIAL FULFILMENT OF THE REQUIREMENT
FOR THE DEGREE OF

MASTER OF SCIENCE (A. H.)

IN ANIMAL NUTRITION.

BY

T. V. L. Satyanarayana Gupta

B. V. Sc.,

Bihar Veterinary College

PATNA

1967.

C E R T I F I C A T E

I certify that this thesis entitled "Studies on the effect of Low-protein and Low-energy on the growth of Tharparkar calves", has been prepared under my supervision, by Sri T.V.L. Satyanarayana Gupta, a candidate for the degree of M.Sc.(A.H.) with Animal Nutrition as major subject and that this incorporates the results of his independent study.

(D. B. MUKHERJEE)
G.V.Sc.,M.Sc.,Ph.D.,
Professor of Animal Nutrition.
Bihar Veterinary College,
P A T N A.

PATNA

The 18th December,
1967.

ACKNOWLEDGMENT

I wish to express my sincere gratitude to Dr. D.B.Mukherjee, G.V.Sc., M.Sc., Ph.D. (Aberdeen), Professor and Head of the Department of Animal Nutrition, Bihar Veterinary College, Patna, for suggesting the problem and for his inspiring guidance, helpful advise and constant encouragemtnt, throughout the course of this work.

I owe a debt of gratitude to Sri P.B.Kuppuswamy, B.A., G.M.V.C.,B.V.Sc.,P.G.(Muk),P.G.(N.Z.),M.S.(Missouri), Principal, Bihar Veterinary College, Patna, for the generous facilities for the work provided by him.

I wish to accord my thanks to Dr. H.R.Mishra,M.Sc., Ph.D.(Minn.), Professor of Animal Husbandry and Manager, Government Cattle Farm,Patna and other staff of the farm, for providing experimental calves and other working facilities.

My sincere thanks are due to Sri R.J.Prasad, M.Sc. (A.H.),P.G.(Stat.),Lecturer in Genetics, Bihar Veterinary College, and Sri S.J.Biswas, M.Sc.(A.H.), Research Assistant, Livestock, Research Station,Patna for their advice on statistical methods adopted in this work.

I also convey my thanks to the entire staff of the Nutrition Department, for their warm interest in the work.

My sincere thanks are also due to Dr.C.Krishna Rao, M.Sc.(Calif.), Ph.D;Director of Animal Husbandry, Andhra-

Pradesh, for his kind arrangement in relieving me and grant of leave, which enabled me to prosecute the course.

Last but not the least, I wish to express my gratitude to my wife, Indira Devi, B.V.Sc. for her constant inspiration and bearing with fortitude, the difficult situation in which she has been placed during tenure of work.

(T.V.L.S.GUPTA)

CONTENTS

CHAPTER - I

INTRODUCTION

INTRODUCTION

The rate at which an animal grows is of great importance to Animal Industry. From economic point of view, rapid growth, early puberty and maturity results in early breeding and quick financial returns. Retarded growth on the other hand increases the age at puberty, delays the breeding, while the animals have to be kept for longer periods without any financial returns.

The economy of profitable rearing and breeding of livestock depends upon the minimal investments with maximum profits spread over a long period.

In livestock industry, a lion's share of recurrent expenditure is spent on feeding of animals. Any fruitful step taken to keep this expenditure at minimum without loss in efficiency, leads to bigger margins of profit.

Though rapidly growing animal consumes more feed than a slow growing animal per day, the total food consumed by them till the attainment of marketable weight or breedable age is considerably less for quick growing one. Naturally farmer prefers to rear the animals for quick growth.

Maximum mature weight of an animal is determined by heredity. Optimum nutritional regime helps in attaining the maximum development thus fixed. Most rapid growth as measured by increase in weight and size, however, may not be ideal for maximum health and life.

A large number of animals which grew very fast often fail to come into profitable production or have an abnormally short productive life. Reports are on record that cows reared on low, medium and high plane of nutrition from their calfhood until their first calving, showed distinctive differences in longevity. Average length of life, reproductive and productive periods were more in animals of low level groups. More animals from high level groups were discarded because of sterility. The low level group possessed the best and high level group, the poorest economic qualities.

Over feeding has shown to shorten the life span due to increased metabolic rate and mechanical obstruction of vital organs and muscles with fat. Under feeding, particularly restriction of calorie intake, increases the life span. The effect of restricted energy intake was to slow down the growth rate and delay the attainment of maturity, after which only the degenerative changes in tissues associated with senescence normally set in.

It is a well established fact that increase in weight should correlate with optimum growth of the diverse organs and glands upon which later production and longevity depend. If the rapid growth obtained is complete and correlated in all aspects, it more likely lengthens the productive life.

While the above facts hold good for animals requiring long and useful productive life, the same do not hold good for animals reared for meat. Animals slaughtered for meat, though they have attained optimum growth at the time of slaughter, they are physiologically immature. Even if these animals are reared under conditions which may ultimately lead to early senescence and short life span, this is of no practical consequence as they are slaughtered when they are still young.

In these animals rapid growth resulting from high plane of nutrition means that they reach the marketable weight in a minimum time. But rapid growth is not necessarily most economic growth from the point of view of efficiency of food conversion. Animals fed on high plane throughout till they attain slaughter weight were less efficient in this respect.

Feeding young stock on high plane when they are in accelerated growth phase and changing them to low plane when they reach retarded growth phase, results in overall efficiency in food conversion. Muscle is the predominent tissue formed during the accelerated growth phase and fat during the retarded growth phase. Thus high plane of nutrition during accelerated growth phase helps to put on more muscle and low plane during later period prevents excess fat deposition. Besides economy in feed, the carcass will have better market value due to better carcass quality (lean meat).

Thus in these animals it seems desirable to maximise the growth rate at certain stages of animal life and to deliberately retard it at other stages.

Feeding standards are very helpful to farmer in feeding his livestock and relieve him of much guess work about what and how much he has to feed in order to get economic returns. Feeding standards for growth must be different for each species and must consist of series of values corresponding to different ages and body weights representing the growth period.

Wolff-Lehmann feeding standards are probably the earliest to be evolved. These values were periodically modified by Morrison and incorporated in the successive editions of his book "Feeds and Feeding" and now is popularly known as "Morrison feeding standards".

National Research Council of U.S.A. has published a series of reports stating the amounts of nutrients advised for the various classes of livestock.

Wood, at the instance of the Ministry of Agriculture and Fisheries, U.K., prepared a bulletin "Rations for Livestock" which was subsequently revised by Woodman.

Indian Council of Agriculture Research, issued a bulletin 'Nutritive values of Indian cattle feeds and feeding of animals' by Sen and revised by Ray to serve as a guide in feeding of animals.

These are only few of the many popular feeding standards. In all these standards the food requirements of each class of livestock are expressed separately for (a) dry matter (b) digestible protein and (c) energy either in terms of "Total digestible nutrients" or 'Therms' or 'Starch equivalents' based on net energy.

India is having 23 million bovine and 20 million ovine population, little over one-fourth of world cattle population. Cattle are indispensable for rural economy. They serve the farmer by motive power for agricultural operations like ploughing, irrigation, rural transport and sugar cane crushers. The edible livestock products like milk, milk products and meat are very valuable items of human diet. Non-edible products like hides, skins, wool, dung, bones, horns and hooves are having considerable monetary value. Though many western countries use machines for motive power, Indian farmer will continue to depend on livestock for some more period.

On rough estimation more than 50% (Rs.1,135 crores) of the annual total agriculture income (Rs.2,200 crores) is derived from cattle. Livestock having such economic potential has to be fed and managed with proper care. At present they are not properly fed due to scarcity of cattle feeds and poverty. India, while it is having 14.2% world human population, has to maintain them on less than 9% of world food grain production. To fill up the gap between requirement and production, nation is importing large quantity of cereals from western countries. As the human needs are given preferance, cattle do not get their legitimate share of grains. Land allocated for raising fodder is also very little. Hence cattle are reared mainly on agricultural by-products like straw and bhusa and industrial byproducts like brans and oil cakes.

Except the few fortunate animals whose owners can afford to feed them sufficiently, majority of animals in general are maintained at sub-optimal level of nutrition. Growth is an important phase of livestock production, as this is the foundation on which the other forms of future production such as milk or draught depends. Very few cattle in India are reared for beef.

Retarded growth from severe under nutrition results in a permanent and substancial loss of production through the animals and their progeny.

Under nutrition may be due to deficiency of either calories, protein or some dietary essentials like minerals and vitamins. Deficiency of energy will immediately check the growth in mass. Deficiency of dietary protein reduces the formation of muscle tissue and growth of internal organs, as protein is their principal constituent. Deficiencies of minerals and vitamins usually have an indirect influence on growth by decreasing the appetite or by adverse physiological effects.

Numerous experiments have been done by various workers in other countries to study the effects of under feeding on performance of growing stock. They found that drastic under feeding arresting the gain in weight could not arrest the skeletal growth in young steers. Deleterious effects of retarded growth depends upon three main considerations : (1) The stage of growth where the retardation is applied,(2) severity of retardation and (3) period for which the retardation is applied.

The permanent stunning is more likely to result, if retardation is applied early in life for a considerable period than if applied later in life when the growth rate is relatively low. Moderate retardation increases the period required to reach the desired weight. Retardation for short period followed by liberal feeding will not materially affect the period. The compensatory growth during the liberal feeding will be high and with better feed conversion.

To judge whether a particular animal is being fed on an optimum plane or not, the requirement of nutrients for that animal should be assessed first. India has several breeds of livestock and climatic conditions are different from place to place. Hence the western standards may not be strictly applicable to the feeding of our livestock and no single feeding standard can be used throughout India.

Studies of various workers between 1930 - '43 indicate that the maintenance requirement of digestible crude protein of adult Indian cattle is considerably less than the allowance recommended by western standards. Fundamental work carried out on endogenous urinary nitrogen excretion and basal metabolic rate suggest that Indian cattle possibly have lower maintenance requirement of energy and protein when compared to western feeding standards.

Works of Sharma (1962) and Mudgal (1965) indicate that there is no advantage in supplying more protein than recommended by Morrison and supplying 20-25% less than the recommended, had no deleterious effects on growth rate.

Some growth studies registered adverse effects on growth with low plane of nutrition. In these experiments both energy and protein supply was lowered. It is difficult to conclude whether energy or protein deficiency or interaction of both were responsible for retardation in growth.

Hence a short term experiment has been designed to study the effects on growth rate in young calves with energy restriction maintaining optimum protein level and vice versa. The results will indicate whether calorie intake or protein intake is the limiting factor in growth at this age of the animals.

....

CHAPTER - II

REVIEW OF LITERATURE

REVIEW OF LITERATURE

The literature reviewed in this chapter are grouped and presented under the following sub-headings.

1. Studies on growth and influence of nutrients on growth.
2. Factors affecting digestibility coefficients.
3. Chromic oxide as indicator in digestion studies.
4. Nitrogen balance studies.
5. Protein reserves.
6. Specific dynamic action.
7. Miscellaneous studies.

1. Studies on growth and influence of nutrients on growth:

Numerous experiments were conducted in India and other countries on growing animals, studying the growth response in them, under various nutritional regimes. Some of them, pertaining to the present study, are reviewed here.

Warth and Misra (1927), Warth (1930-1) and Warth and Gossip (1930) (Citation Sen, 1953) had carried out a number of experiments on the Indian growing calves.

Warth and Misra (1927) reported that six calves of average body weight 212 lb. grew at the rate of 1.09 lb. per day during a feeding period of 11 to 13 weeks, when they were fed on sorghum silage and wheat bran containing 11.4% DCP. Daily intake of DCP was 0.38 lb.

Warth and Gossip (1930) recorded an average growth of 1.15 lb. per day in 8 calves of average body weight 295 lb. Daily consumption of nutrients being 0.62 lb. of DCP and 4.5 lb. of TDN.

They concluded that when rapid growth is not required, much less protein suffices.

Das Gupta (1943) studied the effect of replacement of concentrates to the extent of 50 and 75% by green berseem, on the growth of Hissar heifers, receiving jowar silage and wheat straw as roughage. He obtained growth of 1.3, 0.86 and 0.76 lb. per day for control, 50 and 75% berseem replacement groups respectively.

Lofgreen _et al_. (1951A) studied the growth rate and nitrogen balance in Holstein calves, when fed at different levels of protein and energy. The treatments given were : Group I low energy - low protein (Morrison standards), Group II high energy (15% more)-low protein, Group III low energy - high protein (60% more) and Group IV high energy (15% more) - high protein (60% more). Calves of high energy groups gained 1.4 lb. per day and low energy groups gained 1.2 lb. per day. There was no effect of the levels of protein in both the cases.

Lofgreen and Co-workers (1951b) compared the response of Holstein heifers grown on the protein allowances of the 1936 Morrison feeding standard and on the estimates of Mitchell calculated by the factorial method. The growth data indicated no advantage in supplying more protein to Holstein calves of 150 - 350 lb. body weight, than recommended by Morrison. An intake of somewhat below the lower limit of this standard produced as good gains as did higher levels.

Agarwala and Sundaresan (1956) fed pigs of 8 weeks of age for 6 months on rations containing protein at 31 and 16% in summer and 31 and 20% in winter. In summer, pigs given the lower protein level ate more feed and grew significantly faster than the higher protein group, but in winter the reverse was true. Efficiency of feed conversion was much poorer in winter than in summer, but there was little difference between the protein groups. The economic conversion efficiency was much greater in high protein groups, when the costs of ground-nut-cake and maize were taken into consideration.

Popehina (1956) studied growth of pigs of 70 - 75 kg. body weight. The mean daily intakes of digestible protein (DP) in the different groups were 310, 294, 365 and 414 g. per head per day, 310 g. being the standard. The best daily weight gains of 753 and 745 g. were made by pigs of the first 2 groups with standard protein intake or less and their feed conversion was most efficient. Of all the groups, the first group laid down most meat and the second most fat. The groups with the highest protein intake gained least weight and had the worst feed conversion rate. Nitrogen retention varied in much the same way. Nitrogen excretion was least in first two groups.

Winchester and Ellis (1956) studied the effects of delayed growth on beef cattle. Out of 10 pairs of identical twins, one member of each pair was given a liberal ration, while its twin mate was given ration low in energy but otherwise adequate in respect of protein, minerals and vitamins. Among the low energy littermates, 3 were fed at sub-maintenance level, 3 at maintenance and 4 calves were fed at a level midway between maintenance and liberal ration of controls. After the period of limited feeding, all animals were fed ad libitum till the desired body weight was attained. The results indicated no difference in feed requirement per unit growth between the different treatments. Carcass grade, meat quality and ratio of lean to fat were not affected by delayed growth.

Faltova and Poupa (1957) reported that rats on diets either low or high in protein grew more slowly than rats on normal diets. They suggested that the term "Optimum amount of protein" has not only a minimum but a maximum also.

Mac Donald (1957) studied the effect of plane of intake of TDN on rate and efficiency of gain in identical twin steers. One member of each of the 3 pairs of identical twin Jersy steers was permitted a high, intermediate then low intake of TDN during the experimental period of 60, 40 and 40 days respectively. The other member of each pair was offered low, intermediate and high intakes during the same period. Average net efficiencies of gain in all periods were better for the group on low intake during the first period. With 85% intake of TDN, 87% live weight gain was resulted in low intake group when compared to performence of high intake twins. It was concluded that it might be more economical to restrict feed intakes during the periods of plenty and store the surplus for use during the periods of shortage and thus ensure an adequate energy intake throughout.

Vortilov (1957) fed three groups of 10 month old White head and Kazakh calves with rations containing steppe hay, maize silage, cereals, and sunflower cake. The groups received 100, 125 or 150 g. of DP per feed unit. Weight increases in 4 months were 75.0, 85.5 and 62.2 kg. for the 3 levels of protein. It was concluded that the 100 g. protein usually recommended is inadequate and allowance should be increased.

Winchester et al.(1957) selected 12 pairs of monozygotic beef type cattle aged between 6 - 12 months, and studied the effects of rations of low protein as well as low energy value on growth. Eight different pelleted rations were fed ranging from a calorie maintenance ration that was having only 2.5% DP (ration 1) to rations of relatively high energy value liberally supplied with protein. Animals on ration 1 lost weight while those on other rations made gains that ranged from slight increases to 1.9 lb. per day. When energy intake was held near maintenance, changes in body weight were positively correlated with the level of protein intake. Minimum practical level of protein to be allowed to young cattle on calorie maintenance rations suggested are:-

Weight of the animal(lb.)	100	200	400	600	800	1000
Digestible protein/day(lb)	0.12	0.19	0.31	0.42	0.52	0.60

Crichton et al.(1959) studied the effect of plane of nutrition during rearing, on growth, production, reproduction and health of dairy cattle. They took the Ragsadale (USA) TDN content (11 to 19%) and energy level (71 to 81 therms/100 lb.). When protein was increased, growth and feed utilisation were reduced by 0.10 and 0.60 lb. respectively, while high energy did not alter the growth rate, 0.36 lb. less feed was required per lb. gain.

Hendrickson et al. (1961) studied feed lot performence in Hereford steers by individual feeding in high plane to gain maximum rate of growth to reach 350 lb. body weight (lot 1), moderately for the same length of period (lot 2), and moderately for 350 lb. feed lot gain (lot 3). Average daily gains were 1.72, 1.31 and 1.29 lb. respectively. Moderately gaining calves of lot 2 were no more efficient than full fed steers (lot 1) due to less total gain (270 lb.) or lot 3 due to longer period (65 days) on feed. Slaughter result indicate little difference in carcass composition of calves making different rates of gain.

Riba (1961) studied the effect of level of protein in fattening pigs for bacon. Bacon pigs gained increasingly more weight as protein was raised from an average of 94 to one of 151 g. DP per feed unit. Although feed unit required per kg. gain fell, protein used per kg. gain rose and so did the costs.

Richardson et al. (1961) conducted feeding experiment with heifers and rations having roughage to concentrate ratios of 1:1, 1:3 and 1:5. Highest average gain was obtained with 1:5 ratio and lowest with the 1:1 ratio. Growth rates were 1.97, 2.05 and 2.27 lb. per day for rations having roughage to concentrate ratio 1:1, 1:3 and 1:5 respectively.

Sharma (1962) studied the growth rate for a period of 5 months in two groups of Tharparkar calves aged about 5 months old, with 6 calves in each group, and fed on 2 levels of protein with equal TDN intake. The control group was maintained on DCP and TDN levels at the average of Morrison recommendation, while the experimental group received 25% less of DCP, maintaining the level of TDN. The concentrate portion of the ration was increased by 0.5 lb. per head every three weeks and the green roughage was fed ad libitum. The growth rate for the whole of the experimental period was observed to be 0.90 and 0.70 lb. in the control and experimental groups respectively. Average DCP intake of the control and experimental groups was 0.62 and 0.47 lb. respectively and the average TDN intake was 2.95 lb. per day in both the groups. The difference in the growth rates of calves between the groups was, however, statistically insignificant.

Ranjhan and Talapatra (1963) studied with berseem as growth production ration in Hariana calves weighing 327 to 371 lb. body weight. The calves were divided into 3 groups. Calves in berseem group were fed berseem and wheat straw only whereas bone meal group received bone meal in addition and wheat bran group was supplemented with wheat bran also in addition to berseem and wheat straw. They obtained growth of 0.73 ± 0.08, 0.74 ± 0.03 and 0.98 ± 0.07 lb. per day in berseem, bone meal and wheat bran groups respectively.

Sharma and Talapatra (1963) conducted long duration experiment of 285 days with 15 Murrah calves (8-11 months) to study the growth response in them at different levels of feeding. Calves were divided into 3 groups. One group (High plane) was fed 4 to 8 lb. of concentrate mixture, 2.5 - 6 lb. wheat bhusa, second group (medium plane) 2 - 4 lb. of concentrate mixture, 3 - 6 lb. wheat bhusa and third group (low plane) received 1-2 lb. concentrate mixture and wheat bhusa 1 lb. Each animal of all groups received 5 lb. of green grass in addition to concentrates. Concentrate mixture contained 25% each of gram, crushed barley, G.N. cake and bran.

They obtained growth of 1.4, 0.8 lb. per day in high and medium plane groups respectively. In the low plane group older calves lost and younger calves maintained their weights.

Verma (1963) studied the comparative growth of Tharparkar calves on berseem and concentrates with berseem on equal nutrient intake basis. Twelve,one year old male calves were divided into 2 groups of 6 calves each. One group (experimental group) received berseem green and/or hay ad libitum and the other (control group) received the same amount of DCP and TDN from both concentrates and berseem green and/or hay, the dry matter intake from the concentrates and the roughage being in the ratio of 3:1. The average growth over the experimental period of 3 months was 0.88 and 1.29 lb. per day for the experimental and control groups respectively.

Clanton <u>et al.</u> (1964) reported the effects of protein and energy levels on growth of beef cattle. 56 animals were divided into 4 groups consisting of 14 calves in each. One group served as control (HP/HE) fed at N.R.C. recommendation levels for calves with growth of 1 lb. per day for protein and energy, second group high protein - low energy (HP/LE), third group low protein - high energy (LP/HE) and last group low protein - low energy (LP/LE). Low protein groups obtained 60% protein of N.R.C. recommendations, while low energy groups received 82 % energy of the N.R.C. recommendations. The experiment was conducted for 140 days. Daily average gain, increase in hieght and heart-girth obtained for different groups are shown below.

	Av.daily gain (lb.)	Increase in 140 days: Height (cm.)	Increase in 140 days: Girth (cm.)
HP/HE	0.81	8.6	13.7
HP/LE	0.44	7.7	7.6
LP/HE	0.44	6.9	9.0
LP/LE	0.24	6.2	5.2

Corroll *et al.* (1964) studied the energy utilisation in heifers as affected by a low - protein, iso - caloric diet. Forty weanling heifers were used in the experiment. They were divided into two groups. Low-protein group received ration containing 2.7% DCP and 53.9% TDN, whereas control group received ration containing 12.5% DCP and 61.5% TDN. During the protein restriction period (108 days) low - protein group gained 0.6 lb. in live weight compared to 27 lb. for controls. Then both the groups were fed with liberal ration containing 10.4 % DCP and 66.5% TDN. Compensatory live weight growth during this period (110 days) was so great that the differences in final weight of paired heifers were not significant.

Mudgal and Ray (1965A) reported the growth rate of Tharparkar calves of National Dairy Research Institute, Karnal, under farm conditions to be 6.81 ± 1.14 kg. per fortnight, 6.44 ± 3.03 kg./month, 11.49 ± 2.10 kg./month in male calves of age groups of 0 - 6 months, 7 - 12 months and 13 - 24 months respectively, and 5.98 ± 1.52 kg./fortnight, 7.11 ± 2.77 kg./ month and 9.40 ± 2.43 kg./month respectively for female calves of corresponding age groups.

The same authors (1965C) reported growth rate of 6.33 ± 1.48 kg./fortnight, 8.67 ± 3.04 kg./month and 11.49 ± 2.9 kg./month for male calves and 6.81 ± 1.14 kg./fortnight, 6.44 ± 3.03 kg./month and 11.48 ± 2.10 kg./month for female calves of age groups 0-6 months, 7-12 months and 13-24 months respectively for Sahiwal calves.

Mudgal and Ray (1965B) showed that reduction by 20% in the level of DCP recommended by Morrison does not affect the growth rate in Sahiwal calves of age groups 6-12 months, provided the TDN intake is maintained at satisfactory level. They used in their experiment 36 calves divided into 3 groups. First group fed at 20% below, second at Morrison standards and third at 20% above Morrison standard as far as DCP intake is concerned.

TDN supply was kept at Morrison's average and equal in all groups. Experiment was conducted for 12 months. The average per day gain of male calves was 416 g. in first and third groups and 393 g. in the second group.

Dalai (1966) studied for a period of 4 months, the growth rate in Tharparkar calves fed at 3 levels of nutrition. He had four calves in each group. Group I as control received ration at Morrison standard, group II received 25% extra concentrates and group III 50% extra concentrates over the control group. Green paragrass fed ad libitum served as roughage.

Average growth rate in calves was 360, 500 and 645 g./ day in groups I,II and III respectively. DCP requirement for 1 kg. gain in body weight was 1.1, 1.0 and 0.9 kg. for groups I,II and III respectively. Corresponding figures for TDN were 6.54, 5.64 and 4.70 kg.

2. <u>Factors affecting the digestibility coefficients</u>:

Proximate analysis of a feeding stuff gives a rough idea of the nutritive value of the feed. Digestibility of the feed and its nutrients indicates the extent, an animal can digest and assimilate the nutrients in the feed.

Determination of digestible nutrients in a feed eliminates a highly variable loss, namely undigested faecal loss and places the feed upon a much more nearly comparable basis as regards its actual physiological value. The digestibility of a ration depends upon several variable factors like level of feeding, nutritive ratio and fibre content of the feed and the ratio of concentrate to roughage in the ration etc. Voluminous literature is available on the factors affecting the digestibility coefficients but reference is confined to only few of them which facilitate the discussion later on.

Armsby (1930) mentioned that faeces contains some of the unresorbed bile constituents which includes in the ether extract fraction of the faeces; while their amount is small, the feed of the farm animals is also usually poor in ether extract and consequently the error in the computation of the percentage digestibility may be relatively large.

Seshan (1932) showed that apparent digestibility of EE in the feed will be lower if the EE content in the feed itself is low. He divided the EE components into unsaponifiable matter and total insoluble acids and found that digestibility of unsaponifiable matter may be even negative. He concluded that some of the unsaponifiable matter found in the faeces is derived from the body and is not an undigested fraction of the ingested substance.

Das Gupta (1943) reported that apparent digestibility of fat decreases with the decreased quantity in the ration. The digestibility of EE appears to be proportional to the amount present in the ration. In his experiment "Green berseem as a substitute for concentrates for economic feeding of dairy cattle", he obtained average digestibility coefficients for EE 84.43% for 'concentrate mixture alone' group, 70.59% for '50% replacement by berseem' group and 60.14 for '75% replacement by berseem' group. The EE content was highest in ration of 'concentrate alone' group and lowest in the ration of '75% berseem replacement' group.

French (1956) conducted digestibility trials with Zebu-oxen, feeding them with chaffed hay only, at different levels (to supply 75, 80 and 100% of maintenance allowance). The digestibility of crude fibre was found to increase with each decrease in hay intake.

Lassiter <u>et al</u>.(1956) studied the effect of varying hay-grain rations in dairy cows. The hay fed was having CP 15.5%, TDN 61%. The results are given below.

	Hay:grain 80:20 (%)	Hay:grain 50:50 (%)	Hay:grain 20:80 (%)
Digestibility of:			
Dry matter	65.9	69.3	73.8
Crude fibre	54.2	49.1	36.0
Crude protein	73.3	74.6	76.5

Makela (1956) reported that when cows were fed to appetite, dry matter was retained in the rumen for 24 hours, but for 2 to 3 days when only one-third full feeding was allowed. With young bulls same proportion of the feed was retained in the rumen somewhat longer. Bulk or filling capacity of feed was found to be more closely related to its dry matter content than fibre, ballast or water content.

Bloom <u>et al</u>.(1957) reported that increasing the proportion of concentrates in the diet from 25 to 85 %, led to an increase of digestibility of D.M. from 54.5 to 63.1% and similar increases were found for digestibility of C.P., E.E. and N.F.E. Digestibility of C.F. was highest at 41.5% with 45% concentrates in the diet and least at 20.7% with 85%. As the level of feeding fell from high to low, of the proximate constituents of the ration, only crude fibre digestibility showed much variability, increasing from 27.9 to 35.3%.

Putnam and Loosli (1957) studied the productive and digestive efficiency of cows consuming rations containing 80, 60 and 40% D.M. from roughage and balance from concentrates. As the proportion of concentrate in the ration became larger, the apparent digestibility coefficients of mixed rations increased for D.M., C.P., E.E., N.F.E. and total C.H.O. The apparent digestibility of C.F., however, decreased as the proportion of concentrate in the ration increased.

The same authors (1959) obtained similar results in another experiment.

Witczak (1957) used Merino sheep with rumen fistulae bags with hay, suspended in the rumen for study of decomposition of fibre. When concentrates supplying 77 and 98 g. of D.P. per feed unit for 2 groups respectively with N.R. of 1:8.8 and 1:7.1 were given, the amount of fibre decomposed in the rumen of sheep on diet lower in protein was slightly greater. Examination of rumen contents 12, 36 and 60 hrs. after eating the ration of hay and concentrates showed that with time, contents of dry matter and fibre decreased, fibre more than dry matter.

Paloheimo et al.(1959) found that the mean retention time of dry matter in the reticulo-rumen was significantly negatively correlated, with the amount of dry matter eaten per 100 kg. body weight. When part of the hay ration was replaced with concentrates, the clearence of hay constituents from the reticulo-rumen seemed to be retarded,probably because the concentrates were cleared rapidly, the net effect was equivalent to a reduction in a ration consisting entirely of hay.

Hartfiel (1960) encountered difficulty in analysis of faeces of calves from the often high fat content. It was found best to use fresh faeces hydrolysed with hydrochloric acid and dried rapidly for 2 hrs. at 95°C before being extracted to avoid the inclusion of ether extract fraction of body origin.

Richardson et al.(1961) in a digestion study with Hereford steers observed a highly significant increase in crude fibre digestion with roughage to concentrate ratios 1:3 and 1:5 over the 1:1. Crude fibre digestion was highest with the 1:3 ratio. NFE and EE digestion was lowest with the 1:1 ratio. Protein digestion, however, was not affected by changes in the roughage to concentrate ratio.

Blaxter and Martin (1962) reported that in sheep kept at energy and nitrogen maintenance, production of methane was doubled when casein was given into the rumen, and not affected when given into the abomasum. Net availability of metabolisable energy was only 50.2 % when casein was given into the rumen compared with 64.7% when given into abomasum. It was concluded that the low nutritive value of protein as a source of energy for fat synthesis in sheep is due to its fermentation in the ration than to any peculiarity in the intermediary metabolism of amino acids.

Stone and Fontenot (1964) fed three groups of calves with 3 rations containing 1133, 1164 and 1222 Kcal.Dig.energy/lb. with corresponding protein content of 12.18, 12.51 and 12.29%. Energy concentration in the ration did not significantly influence the apparent digestibility of crude protein and the ether extract. While the digestibility of dry matter, organic matter and nitrogen free extract increased, digestibility of crude fibre decreased with each increase in energy concentration.

3. <u>Chromic oxide as indicator in digestion studies:</u>

Chromic oxide is being increasingly used as an indicator in estimations of digestibility of rations and faeces voided by animals. From the concentration of chromic oxide in faeces, following the administration of known quantity of indicator for a period, the amount of faeces voided is calculated.

In ruminants, chromic oxide exhibits a peculiar diurínal excretion pattern in faeces. Hence, in these animals the concentration of chromic oxide is estimated either from 'total faecal collections' or 'grab samples' of faeces collected from rectum at specified times, which give accurate estimates of total faecal out put. Some of the works on the use of chromic oxide in digestion trials, excretion pattern and factors influencing the pattern are reviewed under this sub-heading.

Estimation of chromic oxide in feed and faeces:-

Schurch et al.(1950) advocated a method of chemical determination of chromic oxide in feed or faeces. The material is ashed in nickle crucible, fused with sodium peroxide. The ash is dissolved in water and volume made up to 500 ml. mark in volumetric flask. The intensity of colour developed is read in a photo electric colorimeter using 440 mμ filter. Calibration curve is determined from standard dichromate solutions. As the Beer-Lambert law is not applicable, plotting y against $1000X\frac{1}{x}$ gave a straight line.

Bolin et al.(1952), to over come the disadvantage of colorimetric determination of fused chromic oxide, suggested another method. Their method involves digestion of the sample containing chromic oxide in a calibrated 100 ml. Kjeldhal flask with oxidising solution containing sodium molybdate, concentrate sulphuric acid and 70-72% perchloric acid until a clear digestion mixture is obtained. After cooling, the volume is made up to the mark and the solution is read in the Evelyn Photo electric colorimeter with 440 m μ filter against distilled water set at 100. Standard curve is prepared by digesting a known amount of chromic oxide, diluting up to the mark and further diluting aliquots to give desired range of dilutions and were read in the colorimeter.

Dansky and Hill (1952) suggested an improvement in the method of Schurch and co-workers by measuring the colour density developed, at 375 mμ in Beckman D.U. Spectro photometer.

Gehrke (1960) followed a volumetric method of estimation of chromic oxide, digesting the ashed material in oxidising solution similar to the one described by Elin et al. (1952) and titrating the solution with standard ferrous ammonium sulphate solution.

Piatkonski et al. (1962) developed yet another volumetric method of estimation of chromic oxide. Ashed faeces or feed is fused with sodium peroxide, dissolved in water and acidified with dil. sulphuric acid. Few drops of bromine water is added and heated. The warm solution is made alkaline with potassium hydroxide and filtered. The filtrate is acidified, 0.5 g. of potassium iodide is added and titrated with standard sodium thiosulphate solution.

Use of chromic oxide as indicator in digestion trials:

Crompton et al. (1951) successfully used chromic oxide as index of digestibility of rations of sheep. Ground oats - Indicator combination was mixed, damped with water and dried in hot-air oven. They used the representative sample from daily faeces collections for chromic oxide estimation and obtained good results.

Irwin and Crompton (1951) reported the use of chromic oxide in human subjects by feeding diets containing indicator at 0.25% level. A composite sample from each individual on test, consisting of major portion of the second to the fifth defecation after the ingestion of the indicator was found to be adequate to determine the coefficient of apparent digestibility.

Schurch et al.(1952) used chromic oxide with good results in digestibility studies with pigs fed ad libitum in the barn. They concluded that chromic oxide method for digestibility estimation is as reliable as a seven day 'marker to marker collection' for swine.

Mc Cullough (1953) observed that the use of indicator techniques offer an apparently reliable measure of contributions of forages to the total ration of a dairy cow under grazing conditions.

Kane and Co-workers (1953) compared various digestion trial techniques with dairy cattle fed orchard grass hay. They secured comparable digestion coefficients with the standard 10 day 'consumption-excretion' method and chromic oxide and plant pigment ratio technique when calculated with both the total collection samples and the average of 3 days partial collection or grab sample. Digestion coefficients calculated by crude legnin and the corrected legnin ratio techniques were significantly lower than that by 'consumption-excretion' method.

Hardison and Reid (1953) examined the adequacy of faeces obtained at convenient sampling times for estimation of D.M. intake in grazing animals. They found that faeces samples procured at 6 a.m. and 4 p.m. and compounded on an equal wet-weight basis during 7 or more days resulted in reliable estimates of dry matter intake.

Hardison et al. (1954) studied the faecal chromic oxide concentration and found that most reliable estimate of total faecal dry matter out put was obtained by compounding samples taken at 6-8 a.m. and 6-8 p.m. Individual cows showed large variations indicating use of more animals.

Lloyd et al. (1955) compared the use of titanic oxide and chromic oxide as index material for determining the apparent digestibility and titanic oxide was found to be inadequate as an index material in the rat diet.

Clawson et al. (1955) used chromic oxide in digestion studies with swine. Their findings were : Excretion of indicator reached equilibrium in 3-4 days of starting the experiment. Results by all methods namely (a) sample over 24 hrs. collection, (b) grab sample at 6 a.m. and 5 p.m., (c) pooled samples of 5-30 a.m., 10-30 a.m., 3-30 p.m. and 8-30 p.m. and (d) total collection for 'seven day period' were in agreement. Most accurate being 24 hr. collection followed by 4 daily samples.

Smith and Reid (1955) used chromic oxide as indicator, of faecal out put for the purpose of determining the intake of pasture herbage by grazing cows. They concluded that the indicator concentration of faeces taken rectally at 6 a.m. and 5 p.m. on seven consecutive days and bulked on an equal weight basis provided accurate estimates of the total faecal out put, recovery being 100.58 ± 0.87%. They found no difference in the accuracy of the estimate between administering the indicator in capsules and that in concentrate feeds. Effectiveness was the same regardless whether chromic oxide was administered at 6 a.m. or 4 p.m. or at 6 a.m. and 4 p.m.

Pigden and Brisson (1956) used chromic oxide in grazing wethers. Their observations were, that the daily excretion pattern of indicator measured at 2 hr. intervals was relatively constant for individual sheep but varied considerably from animal to animal. There was no distinct excretion pattern when the indicator was administered in 6 doses daily.

Kameoka and Co-workers (1956) observed only one peak of chromic oxide excretion pattern when chromic oxide along with feed was given at 9 a.m. and 4 p.m. or at 7 hr. and 17 hr. intervals. When the feed was offered at 12 hr. intervals, two peaks appeared. The daily variation of chromic oxide excretion was found to be ± 10%.

Brisson _et al_. (1957) studied the effect of frequency of administeration of chromic oxide on its faecal excretion pattern by grazing cattle and found that when the indicator was given once or twice daily, its concentration in the faeces changed significantly during the day, but when it was given 6 times daily its concentration remained constant and could be estimated from any one random faecal sample.

Pfander and Co-workers (1957) estimated the digestibility of wheat, sudan grass and corn silage by wethers and steers, both by total collection and chromic oxide technique based on a single grab sample. Indicator technique gave a widely different results.

Balch *et al.* (1957) studied factors influencing the excretion of administered chromic oxide by steers. It was observed that when gelatin capsules with indicator were placed through rumen fistulae, the capsules dissolved in about 5 minutes. The indicator was then rapidly transferred to the omasum, less than 33% remaining in the reticulum after 30 to 60 minutes. When thoroughly mixed with the reticulo-rumen contents, the indicator diminished with the dry matter of the contents. The chromic oxide was more evenly excreted when given before, than when given after feeding.

Kane and Co-workers (1957) measured the digestibility of rations by means of radio active isotope ($Cr^{*}_2O_3$). It was tested in a 3 way comparison of digestibility coefficients obtained by (a) total collection procedure (b) indicator ratio technique (c) radio isotope as a reference material. There was no significant difference in all the results. Radio active method was more convenient from an analytical stand point.

The same authors (1959) conducted similar experiment using radio active chromic oxide $Cr^{51}_2O_3$ and obtained same results.

Bloom *et al.* (1957) made some observations on ration digestibility and on the excretion pattern of chromic oxide in dairy cows. They found that faecal excretion of indicator followed a diurnal pattern. According to them, the absorption of nutrients may proceed at varying rates over a daily period. During high periods of absorptive activity the amount of chromic oxide would increase in relation to the smaller relative amount of ingesta remaining in the tract, reverse being the case during the period of low absorptive activity. They advised collection of grab samples at 12 hr. intervals or at those hrs. when the variation of the indicator in the faeces averages to a mean value for the daily period.

Putnam et al. (1958) gave 20 g. of chromic oxide in gelatine capsules at a standard time once daily. Concentration of indicator in dry matter of faeces sampled every 2 or 3 hr. intervals ranged from 80-120% of the mean values for 24 hrs. and was not affected by different proportions of roughage in the diet ranging from 35 to 100%.

Davis et al. (1958) evaluated the chromic oxide method for determining the digestibility of the rations in dairy cows. They used 8 lactating dairy cows in a 10-day digestion trial in which total collection method of determining digestibility was compared with grab sampling technique using chromic oxide as indicator and showed no significant differences in the results. Analysis of samples from the total faecal composites for the first six days of the 10-day trial, revealed coefficients of digestibility was comparable to those obtained for the entire period.

Hardison and Co-workers (1959) conducted three digestion trials employing dairy heifers or lactating cows. The mean recovery rates of the indicator from totally collected faeces and compounded grab samples of 6 a.m. and 6 p.m. for trials 1,2 chromic oxide would increase in relation to the smaller relative amount of ingesta remaining in the tract, reverse being the case during the period of low absorptive activity. They advised collection of grab samples at 12 hr. intervals or at those hrs. when the variation of the indicator in the faeces averages to a mean value for the daily period.

Putnam et al. (1958) gave 20 g. of chromic oxide in gelatine capsules at a standard time once daily. Concentration of indicator in dry matter of faeces sampled every 2 or 3 hr. intervals ranged from 80-120% of the mean values for 24 hrs. and was not affected by different proportions of roughage in the diet ranging from 35 to 100%.

Davis et al. (1958) evaluated the chromic oxide method for determining the digestibility of the rations in dairy cows. They used 8 lactating dairy cows in a 10-day digestion trial in which total collection method of determining digestibility was compared with grab sampling technique using chromic oxide as indicator and showed no significant differences in the results. Analysis of samples from the total faecal composites for the first six days of the 10-day trial, revealed coefficients of digestibility was comparable to those obtained for the entire period.

Hardison and Co-workers (1959) conducted three digestion trials employing dairy heifers or lactating cows. The mean recovery rates of the indicator from totally collected faeces and compounded grab samples of 6 a.m. and 6 p.m. for trials 1,2 and 3 respectively were 89.4, 89.7 and 97.5%;and 96.4, 90.0 and 89.7%. Average daily faecal dry matter out go was estimated from the grab sample technique with an error of about 12%. Only in trial 2, satisfactory estimates were obtained. They opined that the indiscriminate use of the indicator in the nutritional studies could result in considerable error.

Corbett _et al_.(1960) studied the excretion of chromic oxide administered as a component of paper to sheep. At 10 a.m. sheep were given gelatin capsules containing shredded or unshredded paper impregnated with chromic oxide in an oily suspension. Variation in the excretion of chromic oxide in faeces increased in order with the shredded and unshredded paper and the suspension. With the last diurnal changes showed a reduced concentration of the indicator starting at 4 a.m., those given shredded paper excreted high concentrations at 4 a.m. and 6 p.m. and low concentrations at 2 a.m. and 10 a.m.

Linnerud and Donker (1961) studied the factors affecting the excretion pattern of chromic oxide in faeces of dairy cows on pasture. They found that cows on high concentrate had an excretion pattern that was more variable and about 2 hrs. ahed of cows on low concentrate. Cows fed chromic oxide once a day displayed a curve with one high and one low per day, whereas those fed twice daily had two highs and two lows, with about half as wide a range in values.

Chaudary and Majumdar (1962) examined the comparative usefulness of indicator technique in digestibility determinations in buffaloes, cattle, sheep and goats. All animals were fed on spear grass and ground nut cake at 8% metabolic live weight. In 7-day trials, buffaloes and cattle were given 10 and sheep and goats 5 g. of chromic oxide. Grab samples of faeces gave satisfactory recovery of chromic oxide and digestibility calculated from the indicator, closely resembled values estimated by conventional methods.

Majumdar et al. (1962) studied the use of chromic oxide as an indicator for estimating the faecal out put of bullocks. They conducted seven experiments administering 5 g. of chromic oxide daily to each bullock. Recovery of indicator in collection of faeces pooled for 4 or more days was nearly 100%. Samples of pooled faeces for 7 days gave more satisfactory results than those of shorter periods. Recovery was higher in faeces collected at 7 a.m. than at 4 p.m. Recoveries in 'composite morning and evening grab samples' for a period of 7 days were considered fairly satisfactory.

Majumdar and Gupta (1962) observed the pattern of excretion of chromic oxide in the faeces of grazing animals vis-a-vas stall fed animals. They found that chromic oxide excretion patterns in grazing and stall-fed bullocks and buffalo calves depended on regular feeding, time the marker was given and the management. Chromic oxide appeared in faeces 13 hr. after ingestion.

Deinum et al. (1962) conducted experiments with 3 cows, given 50 g. of paper impregnated with chromic oxide and supplying about 16 g. of the marker. 97.5, 98.6 and 98.4% of the indicator was recovered in faeces. Traces of chromic oxide were found in the liver, lymph glands and kidneys. It is suggested that they might be attributed to the absorption of the marker and may account for the difference between the amount given and that recovered.

Clanton (1962) studied the variations in chromic oxide methods of determining digestibility on hand-fed beef cattle rations. Digestibility coefficients determined by indicator in total collections were lower than conventional method because recovery of chromic oxide was only 95.1%. Grab sample methods resulted in still lower digestibility coefficients. Low energy rations produced by using large amounts of low quality hay resulted in erroneous chromic oxide recoveries. He opined that chromic oxide indicator methods would be appropriate, if only digestibility comparisons between the rations were desired, provided the practical nature of the rations were similar.

Putnam (1962) conducted a survey on the use of chromic oxide in ruminant research in Canada. From out of 101 laboratory reports he received, 45 laboratories have not used the material. 21 laboratories discontinued and 44 laboratories used chromic oxide with equal frequency for digestion and faecal production estimates. Abnormal results were noted in 26 laboratories at one time or other. Most of the laboratories using chromic oxide were satisfied with the technique, but with reservations concerning variations among animals, due to low recoveries or variable excretion patterns.

4. Nitrogen balance studies:

Nitrogen balance shows whether an animal is gaining or losing protein. In growing animals, nitrogen balance indicates the actual increase in protein tissue, thus representing a more exact measure of growth than the increase in weight, which may result from deposition of fat. Nitrogen balance in an animal depends upon the levels of digestible protein and energy in their rations. Some of the works dealt with nitrogen balance and influence of nutrients on nitrogen balance and their relationship with growth in body weight are reviewed here under.

Lofgreen et al. (1951A) conducted a study with dairy calves on the effect of energy intake on the efficiency of protein utilisation as measured by nitrogen balance. Their findings were : (1) 200% increase in non-nitrogen TDN brought about a marked increase in the efficiency of utilisation of the nitrogen available above maintenance requirements, when calves were on the low protein intake. (2) When the animals were consuming the high protein level, an increase in the energy intake brought about no increase in nitrogen retention.

Fontenot et al. (1955) showed that in bullocks on low protein ration (8% protein), nitrogen retention was progressively depressed by increasing amounts of cerelose. With high protein rations (10% and 12% protein) the nitrogen retention was increased by addition of cerelose.

Rosenthal and Allison (1956) reported that in adult rats, with uniform daily intake of 250 mg. of casein in the diet, supply of 43 Cal. of energy per day maintained the body weight, 74 Cal. per day increased body weight and supply of 18 Cal. resulted in loss of weight. N-balance decreased as Cal. were reduced but practically remained constant, at each level of energy intake.

Brisson et al. (1957), from a study of growth rate and N-balance trials, found that retention of nitrogen was best when apparent digestible protein supply was 31.5% of the intake of digestible energy and growth was best when protein supply was 24.3% of energy, with rations adequate in protein, but given at different levels of intake. Each 100 g. of body weight gain per day required 268 dig. Calories, associated with a retention of 3.22 g. of nitrogen, in calves.

Cunningham et al. (1958) conducted further studies with calves and reported that at protein intake levels upto 12% of body weight per day, growth rates agreed closely with values predicted from intake of protein and energy, but at 14%, actual growth rates were lower.

Cunningham (1960), fed pigs of about 50 kg. live weight with rations containing 16, 26 and 33% protein in amounts calculated to supply 33 Kcal. energy/kg. body weight. Pigs given 16% protein gained on average 42 kg. and retained 108 g. of nitrogen in 6 weeks, pigs given 26% protein lost on average 1.2 kg. and retained 200 g. N and those given 33% protein gained on average 0.6 kg. and retained 241 g.N for the same period. Apparent digestibility of protein rose with increase in dietary protein.

Riba (1961) studied the effect of level of protein in fattening pigs for bacon. When two groups of pigs were given 88 and 117g.D.P. per feed unit, at the same level of dry matter intake, group with high protein intake excreted more nitrogen in the urine. Retention of nitrogen was 39.49% of the low and only 23.44% of the high intake.

Whitelaw et. al.(1961), fed calves of 11 weeks old on 8 concentrate diets, equal in energy value but crude protein content varying from 11.6 to 22.6% having different amounts of ground nut meal. Feed was offered at 8% of metabolic body weight ($W^{0.74}$). N-retention rose with increasing crude protein in the diet upto a level of 19-20%. Maximum gain was 475 g.per day, and on average, gains contained 2.88% N.

Sharma and Talapatra (1963) studied growth response in buffalo calves at 3 levels of feeding namely, high, medium and low plane. The average balance of nitrogen and growth among calves of different groups were in order + 37.50 ± 3.88 g., 1.4 lb., + 12.69 ± 1.49 g., 0.88 lb. and + 4.81 ± 0.55 g.,-- per day for high, medium and low planes respectively. Among the calves of low plane, older calves lost weight and younger calves maintained.

Iwao Tabaki and Junichi Okumara (1964) reported that in White Leghorn birds, with increase in nitrogen intake, excretion of urea and ammonia increased. Protein intake being constant, energy intake of standard and 75% of standard levels, maintained urinary nitrogen excretion and birds grew at 6 and 8 g. respectively in 8 days. When 50% and 25% of the standard was given urinary nitrogen excretion increased and birds lost 150 and 550 g. of body weight respectively for the same period.

Stone and Fontenot (1964) studied the effect of energy level of fattening rations on nitrogen utilisation by steers. They fed three groups of calves with 3 rations containing 1133, 1164 and 1222 Kcal DE/lb. and 12.18, 12.51 and 12.29% DCP respectively. They found that the level of digestible energy of feed had no significant effect on nitrogen retention.

Mudgal and Ray (1965D) fed calves with TDN at Morrison scale and protein at three levels, group A, 20% above; B, Morrison scale and C, 20% below Morrison scale. Nitrogen balances of experimental calves were on average 13.62 ± 3.27, 11.08 ± 3.54 and 8.40 ± 1.24 g./day for groups A, B and C respectively in the first metabolism trial. Corresponding figures for the second trial being 22.08 ± 8.30, 19.48 ± 5.12 and 12.15 ± 1.63 g.

5. <u>Protein reserves:</u>

A liberal protein intake regularly, tends to result in a small increase in body, which is referred as 'protein reserve' or 'deposit protein'. The increment thus built up, tends to disappear, on a low-protein diet. The references on 'protein reserves' in livestock are scanty. Some of the available literature is reviewed below.

Lofgreen et al.(1951A) studied the influence of energy intake on the nitrogen retention of Holstein heifer calves and reported that increase in protein intake, while maintaining the TDN constant, permitted growth made up of higher proportion of protein than that of low protein calves which gained at the same rate.

Lagrutta and Cilento (1954) reported that refeeding after a period of restriction in growing rats resulted in storage of large quantities of organic nitrogen compounds or compounds with a high proportion of nitrogen in the muscle and liver.

Jacobus et al.(1965) demonstrated the presence of "protein reserve pool" in liver, muscle and bone of the cocks. During protein depletion, liver lost the greatest percentage of its nitrogen, but in terms of total body nitrogen loss, muscle and probably bone lost most nitrogen. The livers from repleted cocks had a higher total nitrogen content than those from cocks that did not retain nitrogen during repletion period.

Gopalan and Narasingarao (1966) examined the extent of 'labile protein stores' and their response to protein feeding in under-nourished adult subjects. With a protein free diet, urinary nitrogen decreased to a nearly steady value within 2 to 3 days indicating poor labile protein stores in these subjects. With diets containing protein, considerable nitrogen was retained.

6. Specific dynamic action:

The increase in heat production, following the ingestion of food, or a specific nutrient, is referred as 'specific dynamic action'. Heat increment results in a significant loss of the ingested energy, the extent of which is influenced by various factors. Some of the works on the subject are reviewed here.

Rubner(1902) (cited by Blaxter,1956) demonstrated that in man, the amino acids that are incorporated into body proteins exert no heat effect (SDA), whereas if they are deaminated, there is considerable (30%) increase in heat production. Part of the combustible energy of the amino acids will be excreted in the urine as urea and other metabolites which amounts to 16% of the heat of combusten of protein metabolised.

Hawkins (1952) described the specific dynamic action quantitatively as the energy increment to the basal, which results from food utilisation. For any one food or food mixture, the total increment is proportionate to the amount fed. Foods high in protein have the greatest effect. It follows, that under such conditions, if the calorie value of the food given does not exceed the basal expenditure plus the increment, there will be negative calorie balance.

Armstrong and Blaxter (1956, 1957A,B and C) conducted a series of experiments with sheep, to study the heat increment of volatile fatty acids, and found, that acetic acid increases the heat increment considerably. They concluded, since the products of digestion of fibre are fatty acids and the proportion of acetic acid increases with fibre content, the heat increment of feed increases with its fibre content. Further, they found that the heat increment of high protein dried grass was about 50% above the medium protein dried grass.

Bogomolov (1960) studied the SDA of protein feeds in cattle. He found that protein free diet produced a clear reduction in oxygen consumption of about 32% compared with that on standard ration. After transfer to green maize oxygen consumption rose again by 33% for cows and 38% for calves and even more when high-protein mixture including clover and vetch was given. It was calculated that 1 g. protein of green maize gave heat increment in calves by 3.2 Kcal. and 1 g. protein from clover, vetch and oats mixture increased it by 7.86 Kcal.

Cahn and Houget (1960) argued, that carbohydrate supplied in excess of what can be sotred is rapidly converted into fat and that it is the heat liberated in this process that is lost in specific dynamic action. Since comparatively little nitrogen can be stored in the body when given in excess of requirement, the SDA of protein is high. Since fat can be stored almost without limit, it has little or no SDA.

Lery (1960) studied the influence of nutritional state of pig on basal metabolism. He used pigs weighing between 29 to 64 kg. Dry matter intake varied from 450 to 1300 g. per feed and nitrogen intake from 0 to 42 g. Correlation coefficient between oxygen consumption and nitrogen intake averaged + 0.654 ± 0.097, but there was little effect of dry matter intake on basal metabolism.

Rokushima (1961) reported that basal metabolic rate of rabbits was not affected by changes in protein supply. The SDA of glycine or the hydrated product of protein was significantly high in them on a high-protein diet and low in those on a low-protein diet.

Hartsook and Hershberger (1963) examined the influence of low, intermediate and high levels of dietary protein on heat production of rats. They reared 28 rats on isocaloric but containing 8,25,41 and 57% protein diets. All the rats were fed in equal quantities. SDA of the food and the total heat production (gross energy of food minus the sum of energy of excreta and energy of the weight gain) of the animals decreased as the dietary protein increased from 8 to 25% and then increased as the dietary protein increased from 25 to 57%. Weight gain, feed efficiency were at maximal values at 25% level of dietary protein.

7. <u>Miscellaneous studies:</u>

The literature, which could not be reviewed under any of the previous sub-headings, are reviewed here under.

Blaxter (1951) reported that in young Ayrshire calves during nitrogen free feeding period, the metabolic faecal nitrogen was 0.427 ± 0.013 g./100 g. dry matter ingested. The endogenous urinary nitrogen was 81.9 mg./day/kg. body weight.

Irvin *et al.* (1951) studied 'Net energy Vs. TDN' in evaluating the efficiency of an all-alfalfa hay ration for milk production. The actual milk production during all-alfalfa hay ration was much closer to that expected on the basis of TDN calculations. No marked increases were observed in milk production when part of the hay was replaced by ground corn, cellulose mix, corn starch, cane sugar, distillers solubles and soybean oil meal, which could not be explained on a net energy basis.

Lofgreen and Kleiber (1953) determined that average metabolic nitrogen excretion was 0.27 g. per 100 g. dry matter intake in the case of young dairy calves.

Blaxter and Graham (1956) showed that energy retention depended on intake. Energy losses in faeces, urine and heat tended to raise as feed intake is increased and losses in methane fell, resulting decline in net energy.

Blaxter (1956) suggested that Kellner's starch equivalents can be expressed in calories as follows:-

1 kg. dig. protein	=	2240 Kcal. as fat in body
1 kg. dig. NFE	=	2360 Kcal. " "
1 kg. dig. Fibre	=	2360 Kcal. " "
1 kg. dig. EE as per the source, in oil seeds	=	5688 Kcal. " "
in grains	=	5003 Kcal. " "
in roughage	=	4508 Kcal. " "
Average	=	5310 Kcal. " "

For losses due to fibre, deduct 1,360 Kcal. for every kg. of crude fibre in 100 kg. of feed.

Crampton <u>et al</u>. (1957), at the instance of Committee on Animal Nutrition of the United States Research Council, suggested a method of converting TDN values to acceptably accurate corresponding caloric figures. According to him :-

$$\text{Carories per gram TDN} = \begin{matrix} \%\ \text{protein} \times 5.65 + \\ \%\ \text{fat} \times 9.3 + \\ \%\ \text{CHO} \times 4.3 \end{matrix} \times (1.018 - 0.0105 \times \%\text{fat})$$

Preston (1966), recognising that the protein requirements of growing-finishing cattle and lambs are a function of body weight, body weight gain and digestibility of the protein in the ration, suggested that daily protein requirement can be expressed by the following equation.

$$\text{Dig. protein for cattle (g.)} = 2.79 W_{Kg.}^{0.75} (1 + 1.90G) \text{ and}$$

$$\text{Dig. protein for lambs (g.)} = 2.79 W_{Kg.}^{0.75} (1 + 6.02G)$$

Where, $W_{Kg.}^{0.75}$ is the metabolic mass and G is the daily gain(Kg.).

.....

CHAPTER - III

MATERIALS AND METHODS

MATERIALS AND METHODS

Experimental animals:

Twelve apparently healthy Tharparkar male calves of age ranging from 11 to 16 months were selected for conducting the experiment at the Government Cattle Farm, Patna. The calves were divided into three comparable groups. First, all the animals were grouped into triplets, consisting calves of similar age and weight, as far as possible. The calves in each triplet were allotted to each group by random distribution. Marginal adjustments were made by transfer of few calves from one group to another so that the average body weight and age of the four calves of each group were similar to the extent possible. The details of distribution of calves are presented in table 3.1.

TABLE 3.1

Distribution of calves in different groups.

Group A			Group B			Group C		
Calf No.	Age*	Wt. (kg.)	Calf No.	Age	Wt. (kg.)	Calf No.	Age	Wt. (kg.)
156/65	1-3-28	100	155/65	1-3-29	118	158/65	1-3-25	134
161/65	1-3-19	130	162/65	1-3-18	112	159/65	1-3-23	100
19/66	1-2-01	126	39/66	1-0-23	128	8/66	1-2-20	96
72/66	0-11-06	96	46/66	1-0-11	102	74/66	0-11-05	114
Group Av. ± S.E.	1-2-06 ±0-19	113 ± 8		1-2-08 ±1-03	115 ±3		1-2-11 ±0-14	111 ±13

*Age in years, months & days on 1-4-67, the date of selection.

The calves of first group symbolised as group A, served as control and were fed on ration according to Morrison feeding standard as general guide. The second group B was fed with a ration giving 20% less of DCP but ensuring equal TDN to that of group A. The third group C was fed with a ration with equal DCP but 20% less of TDN, compared to group A.

The animals were transferred to a separate shed, and fed in individual feeding troughs daily, throughout the period of experiment. The existing ration of the calves was gradually changed to the experimental rations. A period of 30 days elapsed before all the groups continued to consume their quota of the ration. This unusually long preliminary period, was mainly due to the refusal of group C animals to consume the required amount of concentrate consisting of 60% of ground nut cake.

During this preliminary period, calf no.158/65 developed diarrhoea and found to be suffering from helminthiasis. Hence this calf was replaced by another calf no.11/66 of similar weight and comparable age. All the animals were once treated against helminths with "Phenovis". Calf no.159/65 of group C was persistently refusing major portion of its concentrate ration, but observed it readily taking the concentrate mixture B. Hence this calf was transferred to group B displacing calf no.162/65 to group C.

All the animals except those in group C were taking their full quota of concentrates and roughage quite early in the experiment. Calves in group C, probably due to high content of ground nut cake in concentrate mixture, they were not consuming completely till the end of the preliminary period as already mentioned.

By the end of the preliminary period of 30 days, all the calves were consuming their calculated full quota of concentrate and roughage. The feeding trial was conducted for 120 days. The distribution of calves after the expiry of the preliminary period is given in table 3.2.

TABLE 3.2.

Final distribution of calves after the expiry of the preliminary period.

Group A			Group B			Group C		
Calf No.	Age Y. M. D.	Wt. (kg.)	Calf no.	Age Y. M. D.	Wt. (kg)	Calf no.	Age Y. M.D.	Wt. (kg.)
156/65	1- 5-03	106	155/65	1-5-04	133	162/65	1-4-23	121
161/65	1- 4-24	152	159/65	1-4-28	95	8/66	1-3-25	103
19/66	1- 3-06	137	39/66	1-1-28	138	11/66	1-3-20	114
72/66	1- 0-11	100	46/66	1-1-16	115	74/66	1-1-10	122
Group average	1- 3-11	124	-	1-3-11	120	-	1-3-04	115

During the period of experiment, the weather was warm and dry in April, hot in the months of May and June and relatively cool and humid during the months of July, August and September with occasional rains. Wheather data during the period, consolidated from the records of the neighbouring "Regional Potato Research Institute", Patna is given in table 3.3.

TABLE 3.3.

Average weather data during the experimental period.

Month	Average Temperature Maximum (°F)	Average Temperature Minimum (°F)	Average Relative humidity (%)	Total rain fall m.m.
April	96.2	69.0	86	28.7
May	100.7	76.5	87	29.0
June	101.6	80.9	76	21.3
July	93.3	79.6	87	158.8
August	89.6	78.0	91	213.4
September	89.1	77.1	96	476.1

Computation of rations:

Soon after selection, the appetite of the calves were determined for computing rations, so as to ensure their intake according to the calculated levels. In addition to the usual 1 kg. of farm concentrate mixture, weighed amounts of Paragrass was fed to each calf separately for 3 days. The dry matter intake of individual calves ranged between 2.5 to 2.75 kg./day. To avoid the incidences of feed refusal, it was decided to limit the dry matter intake of each calf to 2.5 kg./day to start with.

The average body weight of calves was 113 kg. (250 lb.) Morrison (1959) recommendation for this weight range of calves is, dry matter 2.68 - 3.26 kg., DCP 280 - 315 g. and TDN 1.89 to 2.27 kg./calf/day.

Taking into consideration, the proximate composition of feeding stuffs, as recorded by previous workers in this laboratory and digestibility coefficients of nutrients as mentioned in the bulletin, "Nutritive value of Indian Cattle feeds and feeding of animals" by Sen and Ray (1964), digestible nutrients of the feed stuffs used in the ration were presumed to be as follows for the purpose of computation of rations.

Name of the feed stuff	DCP (%)	TDN (%)	Remarks.
Wheat bran	10.63	68.9	Fresh matter basis
Ground nut cake	32.45	71.3	-do-
Green Paragrass	4.30	54.5	Dry matter basis.

Ration consisted of three concentrate mixtures, one for each group of calves, containing ground nut cake and wheat bran in different proportions, to give the desired protein level; mineral mixture and salt; and green Paragrass as sole roughage.

Concentrate mixtures composition

Feed stuff	Ration A (Kg.)	Ration B (Kg.)	Ration C (Kg.)
Powdered ground nut cake	20	4	60
Wheat bran	80	96	40
'Avlomin' mineral mixture (I.C.I.)	1	1	1
Salt	2	2	2
Total	103	103	103

Taking into consideration, the proximate composition of feeding stuffs, as recorded by previous workers in this laboratory and digestibility coefficients of nutrients as mentioned in the bulletin, "Nutritive value of Indian Cattle feeds and feeding of animals" by Sen and Ray (1964), digestible nutrients of the feed stuffs used in the ration were presumed to be as follows for the purpose of computation of rations.

Name of the feed stuff	DCP (%)	TDN (%)	Remarks.
Wheat bran	10.63	68.9	Fresh matter basis
Ground nut cake	32.45	71.3	-do-
Green Paragrass	4.30	54.5	Dry matter basis.

Ration consisted of three concentrate mixtures, one for each group of calves, containing ground nut cake and wheat bran in different proportions, to give the desired protein level; mineral mixture and salt; and green Paragrass as sole roughage.

Concentrate mixtures composition

Feed stuff	Ration A (Kg.)	Ration B (Kg.)	Ration C (Kg.)
Powdered ground nut cake	20	4	60
Wheat bran	80	96	40
'Avlomin' mineral mixture (I.C.I.)	1	1	1
Salt	2	2	2
Total	103	103	103

The nutritive value of the mixtures was worked out to be DCP and TDN content in order 15.0, 69.0; 11.5, 69.0; and 23.0, 70.3 percent for the mixtures A,B and C respectively. Sufficient quantities of powdered ground nut cake and wheat bran were stored separately, in advance, to minimise the variations in chemical composition of the concentrate mixtures. The manufacturers of 'Avlomin' brand mineral supplement, claimed that their product is in accordance to the I.S.I. specification and the flurine content is limited to 0.004 %.

Indian Standards Institute in their specification no. IS:1664-1960, specified the requirements for mineral mixture for supplementing the cattle feeds. According to them the mineral mixture should contain:-

Moisture	-	Max.	7%
Calcium	-	Min.	22.0%
Phosphorous		Min.	9.5%
Salt	-	Min.	30.0%
Iron	-	--	0.4 to 0.6%
Iodine as KI		--	0.2 to 0.3%
Copper	-	--	0.06 to 0.1%
Manganese	-	--	0.09 to 0.12%
Cobalt	-	--	0.12 to 0.02%
Flurine	-	Max.	0.025%
Spores	-	--	Spores of Bacillus anthracis, Clostridium botulinum, Clostridium chauvoei, Clostridium septicum should not be present.

Every time the concentrate mixtures A,B and C were prepared in quantities sufficient for a month. All the ingredients in the rations mentioned earlier were well mixed and stocked in separate gunny bags and were labelled properly before stacking them.

Daily rations for experimental calves and their estimated digestible nutrient supply, at the commencement of the experiment are as follows:-

Calves of group A.	D.M. (kg.)	DCP (g.)	TDN (kg.)
1.75 kg. concentrate mixture A	1.59	262	1.207
4.00 kg. green Paragrass	1.00	42	0.544
Total nutrient intake/calf/day.	2.59	304	1.751
Calves of group B.			
1.75 kg. concentrate mixture B	1.59	201	1.207
4.00 kg. green Paragrass	1.00	42	0.544
Total nutrient intake/calf/day.	2.59	243	1.751
Calves of group C.			
1.00 kg. concentrate mixture C.	0.91	237	0.703
5.00 kg. green Paragrass	1.25	54	0.681
Total nutrient intake/calf/day.	2.16	291	1.384

By giving the above mentioned rations, group A calves were receiving DCP at Morrison's average standard and dry matter and TDN intake slightly less than the minimum recommendation. Calves of group B were ensured same dry matter and TDN intake but 20% less DCP than group A. Group C received same DCP but TDN intake was 20% less than group A. Inspite of larger amount of roughage given to this group, group C was offered less dry matter than the other two groups because of the necessity of 20% less TDN intake. Throughout the period of experiment, same amounts of green Paragrass were given to each animal. The ration of concentrate mixture was however, increased by 100 g. every month to meet the increased maintenance requirement. The above mentioned nutritive values are only tentative. The actual values based on our digestibility coefficient data, were presented in the chapter 'Results and discussion'.

Feeding and management practices:

All the calves were housed in a shed and stall fed in individual feeding troughs. Required weighed amounts of concentrate mixture were given between 9 - 10 a.m. At 10 a.m. and 4 p.m. all the animals were offered water ad libitum. At 4 p.m. required weighed amounts of green Paragrass (chaffed) were given to calves. Orts were minimum during the period of experiment. Whenever there were left-overs they were weighed and samples were taken to the laboratory for dry matter estimation and making necessary entries in net dry matter and nutrient intake.

Chemical analysis of feeds:

Sampling:- All samples were collected from 10 or more different places in each bag and different bags and well mixed to form a representative bulk sample. Green Paragrass was always sampled at the time of offering it to the calves. About 500 g. of sample was collected from 10 or more different places of the chaffed heap of Paragrass and brought to the laboratory in a wide mouthed jar and the dry matter was estimated. Dry matter content of the Paragrass was estimated weekly once during the first three fortnights and, daily for the remaining period of the experiment, to facilitate the correct determination of dry matter intake from the roughage.

After drying in hot air oven, the grass sample was bulked for a fortnight from which, representative samples were taken for estimation of crude protein and for monthly proximate analysis of all nutrient components.

Methods of chemical analysis used for feeds were as under:

Moisture	...	By keeping a weighed quantity of the feed in hot air oven at 100°C to a constant weight as described by A.O.A.C.(1940).
Crude protein	...	By Kjeldhal method as described by A.O.A.C.(1940).
Crude fibre	...	Weende method as given in A.O.A.C.(1940).
Ether extract	...	Soxhlets extration using Petroleum ether (B.P. 40-60°C for 8hr)

Total ash ... Ashing weighed quantity of material in silica basin in muffle furnace at 600°C for 5-6 hrs.as given in A.O.A.C.(1940).

Nitrogen free extract. ... By difference.

Weighing of calves:

All the calves were weighed at the beginning of the experiment and then at fortnightly intervals, to record the growth in each calf. Whiteman *et al*.(1954) and Koch *et al*.(1958) had suggested to weigh the animals after shrinking them for a period of 10-15 hrs., to reduce the errors in weighing due to variability of ingesta in the digestive tract.

On each occasion, the calves were weighed in the morning at 7 °clock, before watering and feeding. The last intake of feed and water would have been in the previous evening at 5 °clock. Thus about 14 hrs. of shrinking of calves was ensured at the time of weighing. The calves were weighed on two consecutive days and the average of the readings reckoned as body weight. The increase in body weight in a fortnight was the growth during the period.

Body measurement:

Body measurements were recorded for all calves at the beginning and at the end of the experiment. Height of the calves at the withers, length between the points of shoulder and the hip and heart-girth behind the shoulders were measured, to know the differences if any in the increase of these measurements in different groups.

Metabolism trial:

At the end of feeding trial, digestion trial and simultaneous nitrogen-balance study were conducted. Two calves from each group were selected at random and were shifted to a separate shed. General instructions given by Lander (1949), for conducting metabolism trial, were observed.

It was proposed to determine the faecal out put, both by conventional quantitative collection of faeces and chromic oxide indicator technique by grab sampling. In the absence of readily available A.R. grade, 'Dampha' laboratory reagent grade chromic oxide was used.

For collection of urine, a conical rexine bag was tied round the belly of the calf by means of tape, so that the prepucial opening snugly lie in the funnel of the bag. The ends of the tape aretied to a side of the body. To the bottom of the bag, a flexible plastic funnel was fitted and connected to a long rubber tubing, the other end of which was kept in urine receptacle. As and when the calf passed urine, urine is drained through the funnel and tube into the receptacle. It was ensured that the calves could lie down comfortably with the device in place. During the trial period, occasionally the tapes were loosened to allow free aeration of the enclosed sheath. For the rest of the period, the tapes were secured the differences if any in the increase of these measurements in different groups.

Metabolism trial:

At the end of feeding trial, digestion trial and simultaneous nitrogen-balance study were conducted. Two calves from each group were selected at random and were shifted to a separate shed. General instructions given by Lander (1949), for conducting metabolism trial, were observed.

It was proposed to determine the faecal out put, both by conventional quantitative collection of faeces and chromic oxide indicator technique by grab sampling. In the absence of readily available A.R. grade, 'Dampha' laboratory reagent grade chromic oxide was used.

For collection of urine, a conical rexine bag was tied round the belly of the calf by means of tape, so that the prepucial opening snugly lie in the funnel of the bag. The ends of the tape are tied to a side of the body. To the bottom of the bag, a flexible plastic funnel was fitted and connected to a long rubber tubing, the other end of which was kept in urine receptacle. As and when the calf passed urine, urine is drained through the funnel and tube into the receptacle. It was ensured that the calves could lie down comfortably with the device in place. During the trial period, occasionally the tapes were loosened to allow free aeration of the enclosed sheath. For the rest of the period, the tapes were secured properly to prevent loss of urine.

The works of Staples (1951), King (1960) and Clanton (1961) were in favour of 7-day collection period, which gave coefficients comparable in accuracy to the 10-day collection period. Hence 8-day collection period, preceded by another 8-day preliminary non-experimental period was thought reasonable. 8-day preliminary period was for the calves to accustom to the urine collection fittings and permit the indicator attaining equilibrium in intake and excretion.

The same quantities of concentrate mixtures and roughage were used during the trial. 12 g. of chromic oxide, well mixed in concentrate mixture, was offered to each calf. To prevent dustiness and loss of indicator, the mixture was moistened with water.

Quantitative collection of faeces was done mannually and stored in a covered tray, through watchmen kept round the clock for the purpose. 24-hr. faeces collection from each calf was weighed and recorded. The faeces of each animal was well mixed and a representative sample was collected from several places and taken to laboratory in petridishes. Two percent of the total collection was kept in hot-air oven for dry matter estimation. After drying, the faeces was powdered and bulked in wide mouthed glass bottles, for 8 days for further chemical analysis. The total weight of grab samples taken daily was added to the 24 hr.-collection value, for calculating the amount of dry matter excreted every day.

For estimating the dry matter voided by chromic oxide indicator technique, about 100 g. of grab sample of faeces was collected per rectum from every calf at 6 a.m. and 4 p.m. 50 g. of the sample was weighed, dried and bulked for 8 days for estimation of chromic oxide.

24 hr.- urine collection of every calf was measured and recorded. One percent of the daily collection of urine was pooled in a bottle containing 10 cc. of concentrate sulphuric acid as preservative. Eight days pooled urine sample of each calf was stored in separate bottles and labelled for analysis of urinary nitrogen.

Proximate analysis of faeces was done according to methods mentioned earlier. Urinary nitrogen was estimated by Kjeldhal method. Using data of daily nutrient intake from both concentrate and roughage; and nutrient outgo in faeces; digestibility of dry matter, crude protein, crude fibre, nitrogen free extract and ether extract were estimated.

Total nitrogen intake in concentrate and roughage, minus the sum of total fecal nitrogen and total urinary nitrogen excretions, gave the net nitrogen balance of the calf in question.

<u>Determination of dry matter excreted in faeces by chromic oxide indicator technique</u>:

As mentioned earlier, 12 g. of laboratory grade chromic oxide was administered daily in the concentrate mixture to every calf. The intake of pure chromic oxide equivalent was

9.41 g. per day per animal. By knowing the percent of chromic oxide in dry faeces, dry matter voided by each calf was calculated by the following formula:-

$$\text{Average dry faeces voided by calf/day (g.)} = \frac{9.41 \times 100}{\%\ \text{chromic oxide in dry faeces}}$$

Analytical procedure described by Gehrke (1960) was followed for estimation of chromic oxide in faeces. In short, the procedure involves oxidising the chromic oxide in the faeces by an oxidising solution into dichromates and estimating the dichromates by titrating against standard ferrous Ammonium Sulphate solution.

$$Cr_2O_7^{--} + 6Fe^{++} + 16H^{+} \longrightarrow 2Cr^{+++} + 6Fe^{+++} + 7H_2O.$$

<u>Reagents used:</u>

(1) Oxidising solution, prepared by mixing 234 ml. 60% perchloric acid, 150 ml.A.R. 96% sulphuric acid, 116 ml. distilled water and 10 g. of sodium molybdate.

(2) Standard solution of Potassium permanganate (N/10)

(3) Standard solution of Ferrous Ammonium sulphate (N/10)

(4) Phosphoric acid 85%

(5) Perchloric acid 60%.

N.B.- Before use std.potassium permanganate and std.ferrous ammonium sulphate solutions were standardised by titrating with std. oxalic acid,and standard permanganate solution respectively.

<u>Analytical procedure:</u>

Five grams of well mixed faeces sample was taken in a silica basin and ashed. The dry ash was quantitatively transferred carefully into a 250 ml. Pyrex beaker. The basin was rinsed with three 10 ml. portions of oxidising solution. Each time the solution was allowed to remain in the basin for some time and then transferred into the beaker. A quantitative transfer of ash was thus ensured.

The beaker containing ash and oxidising solution was kept over sand bath in fume chamber and slowly heated over Bunsen flame, till dense white fumes of perchloric acid were given off indicating nearing completion of oxidation.

The beaker was removed, cooled and 10 ml. of 60% perchloric acid was added and heated again until white fumes of perchloric acid reappeared. The beaker was removed from the sand bath, cooled and about 50 ml. of distilled water was added. Upon standing, the sulphates, perchlorates and silica settled down leaving a clear yellow-orange solution.

A measured excess of std. ferrous ammonium sulphate solution was added till the solution turned to green. To improve the sharpness of end point, 10 ml. of 1:1 syrupy 85% phosphoric acid was added before titration. Excess ferrous ammonium sulphate was back titrated with std. potassium permanganate solution. The chromic oxide content expressed in percent was calculated as follows:-

$$\% \; Cr_2O_3 = \frac{V_{Fe^{++}} \times N_{Fe^{++}} \times \frac{152.02}{6000} \times 100}{\text{Sample weight}}$$

Where, $V_{Fe^{++}}$ is the volume of std. iron solution used up.

$N_{Fe^{++}}$ is the normality of the std. iron solution used.

152.02 is the molecular weight of the chromic oxide and sample weight representing the weight of faeces sample ashed.

The above formula is derived from the basic equation, that $6Fe^{++}$ reacts with each $Cr_2O_7^{--}$, originated from one molecule of chromic oxide.

Statistical methods:

Wherever possible the data obtained was analysed by the methods described by Snedecor (1961).

Analysis of variance: Analysis of variance helps in deciding whether the results obtained reflect a real difference in response to the two treatments or might have occurred simply because of inherent variations in the animals used. Analysis was done for growth rates recorded under various treatments.

Following is the skeleton of the analysis

Source of variation	D.F.	Total S.S.	Mean square	F.
Between groups	2	A	A/2 = a	a/d
Between fortnights	7	B	B/7 = b	b/d
Group X fortnights	14	C	C/14 = c	c/d
Error	72	D (E-A-B-C)	D/72 = d	--
Total	95	E	---	--

Wherever 'F' was significant, critical difference was obtained to find out significance of mean difference of any two means.

The following formulae were used for obtaining critical difference:-

Critical difference at 1% = t_{01} error d.f. $\sqrt{\frac{2s^2}{n}}$ being $n_1 = n_2$

Critical difference at 5% = t_{05} error d.f. $\sqrt{\frac{2s^2}{n}}$ being $n_1 = n_2$

Where t_{01} or t_{05} is the table value with error degree of freedom.

s^2 is the error mean square.

n is the number of replicates.

The critical difference value thus obtained was compared with the difference of the averages between any two treatments in all combinations.

Mean and standard error:- The following formulae were used to find out mean and standard error.

$$\text{Mean} = \sum_{i=1}^{n} \frac{x_i}{n}/n$$

$$\text{Standard error} = \sqrt{\frac{\sum_{i=1}^{n} x_i^2 - \frac{\left(\sum_{i=1}^{n} x_i\right)^2}{n}}{n(n-1)}}$$

.....

CHAPTER - IV

RESULTS AND DISCUSSION

RESULTS AND DISCUSSION

I. Composition of cattle feeds used during the period of experiment.

(a) Roughage:- Green Paragrass.

Green paragrass was the only roughage used for feeding the calves throughout the experiment.

TABLE- 4.1

Chemical composition of the Paragrass samples used during the experiment (expressed in %).

Fort-night	Duration	Details of the Plot.	Dry matter	Dry matter basis				
				Crude protein	Crude fibre	NFE	EE	Ash
I	5-5-67 to 19-5-67	Plot no.2 upto 7th May, changed to plot 3.	23.0	11.4	-	-	-	-
II	20-5-67to 3-6-67	Pl.no.3 upto 28th May, changed to plot no.16-A	31.5	8.2	30.9	48.5	-	10.4
III	4-6-67 to 18-6-67	Plot no.16-A.	32.5	3.5	-	-	-	-
IV	19-6-67to 3-7-67	Plot no.16-A.	24.4 ±.08	6.6	31.7	50.1	-	9.6
V	4-7-67 to 18-7-67	Changed to Pl. 3 on 10th Jul.	17.7 ±.12	15.3	-	-	-	-
VI	19-7-67to 2-8-67	Plot no. 3	17.5 ±.06	12.2	28.2	47.8	-	9.8
VII	3-8-67 to 17-8-67	Changed to Pl. 6 on 5th Aug.	18.3 ±.09	10.2	-	-	-	-
VIII	18-8-67to 1-9-67	Plot no.6	18.2 ±.06	9.4	36.2	42.8	2.0	9.6
Average for the entire period			22.9	9.6	31.7	47.5	2.0	9.8

Consistent differences were found in the chemical analysis of the Paragrass (Table 4.1) from time to time. Most variation was observed in the dry matter content and crude protein. Dry matter content at the beginning was 23.0% and rose to a maximum of 32.5% by third fortnight. Contrastingly crude protein content reduced gradually from 11.4 to 3.5% on dry matter basis. These changes are due to increasing ambient temperature and the grass gaining maturity and weathering by summer heat. During the months of May and June the weather was very hot and dry with maximum temperature 101.6°F and minimum 76.5°F and relative humidity ranging between 76 - 86%.

Plot No.16-A is having a sewage pump, irrigating the plot with sewage water. During IV fortnight, grass from this irrigated area was cut. During that period the dry matter content decreased to 24.4% and crude protein increased to 6.6%.

In the beginning of V forthight, on 5-7-67 the area received monsoon rains (26.7 mm.). The plants grew luxuriantly and the dry matter content ~~was~~ reduced to 17.7% and the crude protein increased to 15.3% on dry matter basis. During VI, VII and VIII fortnights the dry matter content remained within the range of 17.5 to 18.3%, but crude protein was gradually reduced to 9.4%. On rainy days and few days afterwards, the dry matter reduced considerably due to soaking in rains and getting wet in water stagnated fields. For example, after 26.7 mm. rain on 5-7-67, the dry matter content reduced from 25.28

to 16.80%, likewise on 17-7-67 from 17.47 to 13.10%, on 7-8-67 from 22.31 to 17.30%. A few data on chemical composition of Paragrass obtained by previous workers in this college and else where are tabulated for comparison with the present data.

(Values in percent)

Sl. No.		D.M.	Dry matter basis					Remarks
			C.P.	C.F.	N.F.E.	E.E.	Ash	
1	Sharma (1962)	28.0	7.9	39.5	43.7	1.4	7.6	*
2	Singh (1963)	12.5-31.8	3.65-13.25	23.33-38.57	37.87-45.53	1.19-3.69	7.11-17.39	
3	Mathur *et al.* (1963)	--	15.82	33.13	38.68	2.36	10.01	
4.	Sindhu (1964)	30.9	7.08	27.6	52.8	--	10.96	*
5.	Dalai (1966)	23.0	10.0	44.6	29.0	5.8	10.7	*
6.	Present study	22.9	9.6	31.7	47.5	2.0	9.8	

*Bihar Veterinary College.

The figures obtained in the present study lie within the normal range when compared with others data.

(b) Concentrates:- Only ground nut cake and wheat bran were used as ingredients in the concentrate mixtures. The average composition of these feeding stuffs are given below:-

(In percent on fresh matter basis)

Concentrate	Moisture	C.P.	C.F.	N.F.E.	E.E.	Ash
Ground nut cake	10.92 ±.09	42.93 ±.13	10.67 ±.02	21.92 ±.11	8.40 --	5.17 ±.01
Wheat bran	9.82 ±.02	13.55 ±.01	9.95 ±.43	55.76 ±.03	4.10 --	6.82 ±.13

The result of proximate analysis of ground nut cake and wheat bran samples is in agreement with Sen and Ray (1964).

II. Metabolism trial.

(i) Digestion trial:

Two calves from each group were selected at random and were shifted to another shed for conducting metabolism trial, the details of which were presented in the chapter "Materials and Methods". All the animals consumed the entire quantity of ration offered during the trial, except calf no. 39/66 of group B which left on average 100 g. of green Para-grass (dry matter basis) per day. The calf was healthy in appearance and it was taking its full quota previous to the start of the trial.

(a) Total collection:

On average each animal passed 11 dropings per day. The faeces of all animals was firm and well formed. The dry matter content of faeces on average was 21.23, 21.32 and 19.23 percent for groups A,B and C respectively. Daily faeces excretion, proximate analysis of feeds used during the trial, and proximate analysis of faeces of each calf are presented in tables 4.2 and 4.3. Taking into consideration the quantity of various nutrients consumed by calves in the concentrate mixture and roughage and nutrients excreted in faeces, digestibility coefficients are calculated for each calf. The coefficients are rounded off to the nearest numerical and are presented in tables 4.4A, B and C.

TABLE 4.2

Daily faeces excretion of calves during metabolism trial

Sl. No.	Fresh faeces (kg.)	D.M. (%)	Faeces, Dry (kg.)	Fresh faeces (kg.)	D.M. (%)	Faeces, Dry (kg.)
Group-A						
	Calf No.156/65			Calf No.19/66		
1	4.72	22.7	1.071	4.42	21.0	0.928
2	4.62	22.7	1.048	4.64	21.3	0.988
3	4.94	22.1	1.091	4.98	22.6	1.126
4	5.22	22.6	1.191	4.84	20.1	0.970
5	4.64	22.8	1.058	5.64	23.1	1.303
6	4.58	23.2	1.063	4.98	20.5	1.021
7	4.50	20.4	0.918	6.40	21.5	1.376
8	4.34	18.1	0.780	4.04	22.0	0.889
Average		20.95 ±.25	1.025 ±.017	--	21.51 ±.13	1.075 ±.025
Group-B						
	Calf No.39/66			Calf No.46/66		
1	4.56	23.3	1.062	3.44	22.4	0.771
2	4.36	21.3	0.928	5.20	22.9	1.191
3	3.78	22.1	0.835	5.34	20.7	1.105
4	3.96	23.8	0.942	3.78	20.0	0.756
5	3.92	21.3	0.835	4.84	20.8	1.007
6	3.76	21.2	0.797	4.74	21.7	1.069
7	3.66	18.9	0.692	6.38	19.0	1.212
8	4.46	20.8	0.920	3.88	21.0	0.815
Average		21.59 ±.26	0.876 ±.015	--	21.06 ±.17	0.991 ±.025

TABLE 4.2 (contd.)

Sl.No.	Fresh faeces (kg.)	D.M. (%)	Faeces, Dry (kg.)	Fresh faeces (kg.)	D.M. (%)	Faeces, Dry (kg.)
			Group - C			
	Calf No.162/65				Calf No.11/66	
1	3.40	22.0	0.748	3.74	18.4	0.688
2	3.58	21.7	0.777	4.48	19.9	0.971
3	4.70	22.1	1.039	4.08	16.7	0.681
4	3.54	19.1	0.676	2.80	17.4	0.487
5	4.12	18.1	0.746	3.42	17.8	0.609
6	2.42	18.3	0.443	3.82	18.6	0.711
7	2.80	16.7	0.368	4.42	20.7	0.915
8	4.10	19.0	0.779	3.62	21.3	0.771
Average		19.62 ±.27	0.709 ±.025	--	18.85 ±.21	0.729 ±.021

TABLE 4.3

Proximate analysis of feeds fed, and of faeces voided by calves during metabolism trial (dry matter basis).

Particulars	Chemical analysis in percent				
	C.P.	C.F.	N.F.E.	E.E.	Ash
Concentrate mixture for					
Group A	21.4	10.6	52.9	5.4	9.7
Group B	17.0	10.5	58.9	4.7	8.9
Group C	33.9	11.4	48.4	7.3	9.0
Green Paragrass	9.4	36.2	42.8	2.0	9.6
Faeces of calf no.156/65	9.2	26.9	43.1	5.3	15.5
" " 19/66	8.6	28.6	42.4	5.0	15.4
" " 39/66	9.4	22.0	47.5	6.7	14.4
" " 46/66	9.6	27.7	49.7	7.2	15.8
" " 162/65	9.9	25.2	45.8	2.3	16.8
" " 11/66	9.2	25.8	44.6	2.9	17.5

TABLE 4.4A

Results of the digestion trial - Group A

Particulars	D.M. (g.)	C.P. (g.)	Carbohydrate C.F. (g.)	Carbohydrate N.F.E. (g.)	Carbohydrate Total (g.)	E.E. (g.)
Calf No.156/65						
Intake : (a) Concentrate mixture	1904	407	201	1007	1208	104
(b) Green Paragrass	808	76	293	378	671	16
Total	2712	483	494	1385	1879	120
Outgo : Faeces excreted	1028	95	276	443	719	54
Difference: Apparently digested	1684	388	218	942	1160	66
Percentage digestibility	62	80	44	68	62	55
Calf No. 19/66						
Intake : (a) Concentrate mixture	1904	407	201	1007	1208	104
(b) Green Paragrass	808	76	293	378	671	16
Total	2712	483	494	1385	1879	120
Outgo: Faeces excreted	1075	92	307	456	763	54
Difference: Apparently digested	1637	391	187	929	1116	66
Percentage digestibility	60	81	38	67	59	55
Average percentage digestibility for the group.	61	80	41	67	60	55

TABLE 4.4B

Results of the digestion trial - Group B

Particulars		D.M. (g.)	C.P. (g.)	Carbohydrate			E.E. (g.)
				C.F.(g.)	N.F.E.(g.)	Total(g.)	
Calf No.39/66							
Intake : (a)	Concentrate mixture	1905	324	199	1124	1323	89
(b)	Green Paragrass	,708	66	256	331	587	14
	Total	2613	390	455	1455	1910	103
Outgo :	Faeces excreted	876	82	193	416	609	59
Difference :	Apparently digested	1737	308	262	1039	1301	44
	Percentage digestibility	66	79	58	71	68	43
Calf No.46/66							
Intake : (a)	Concentrate mixture	1905	324	199	1124	1323	89
(b)	Green Paragrass	792	74	275	371	646	16
	Total	2697	398	484	1495	1969	105
Outgo :	Faeces excreted	991	95	275	493	768	71
Difference :	Apparently digested	1706	303	209	1002	1201	34
	Percentage digestibility	64	77	51	67	61	37
Average percentage digestibility for the group.		65	78	54	69	64	40

TABLE 4.4C

Results of the digestion trial - Group C.

Particulars		D.M. (g.)	C.P. (g.)	Carbohydrate C.F. (g.)	Carbohydrate N.F.E. (g.)	Carbohydrate Total (g.)	E.E. (g.)
Calf No.162/65							
Intake :	(a) Concentrate mixture	1231	417	141	473	614	90
	(b) Green Paragrass	1010	95	365	473	838	20
	Total	2241	512	506	946	1452	110
Outgo :	Faeces excreted	709	70	179	325	504	16
Difference :	Apparently digested	1532	442	327	621	948	94
	Percentage digestibility	68	86	65	66	65	85
Calf No.11/66							
Intake :	(a) Concentrate mixture	1231	417	141	473	614	90
	(b) Green Paragrass	1010	95	365	473	838	20
	Total	2241	512	506	946	1452	110
Outgo :	Faeces excreted	729	69	188	325	513	21
Difference :	Apparently digested	1512	443	318	621	939	89
	Percentage digestibility	67	87	63	66	65	81
Average percentage digestibility for the group.		67	86	64	66	65	83

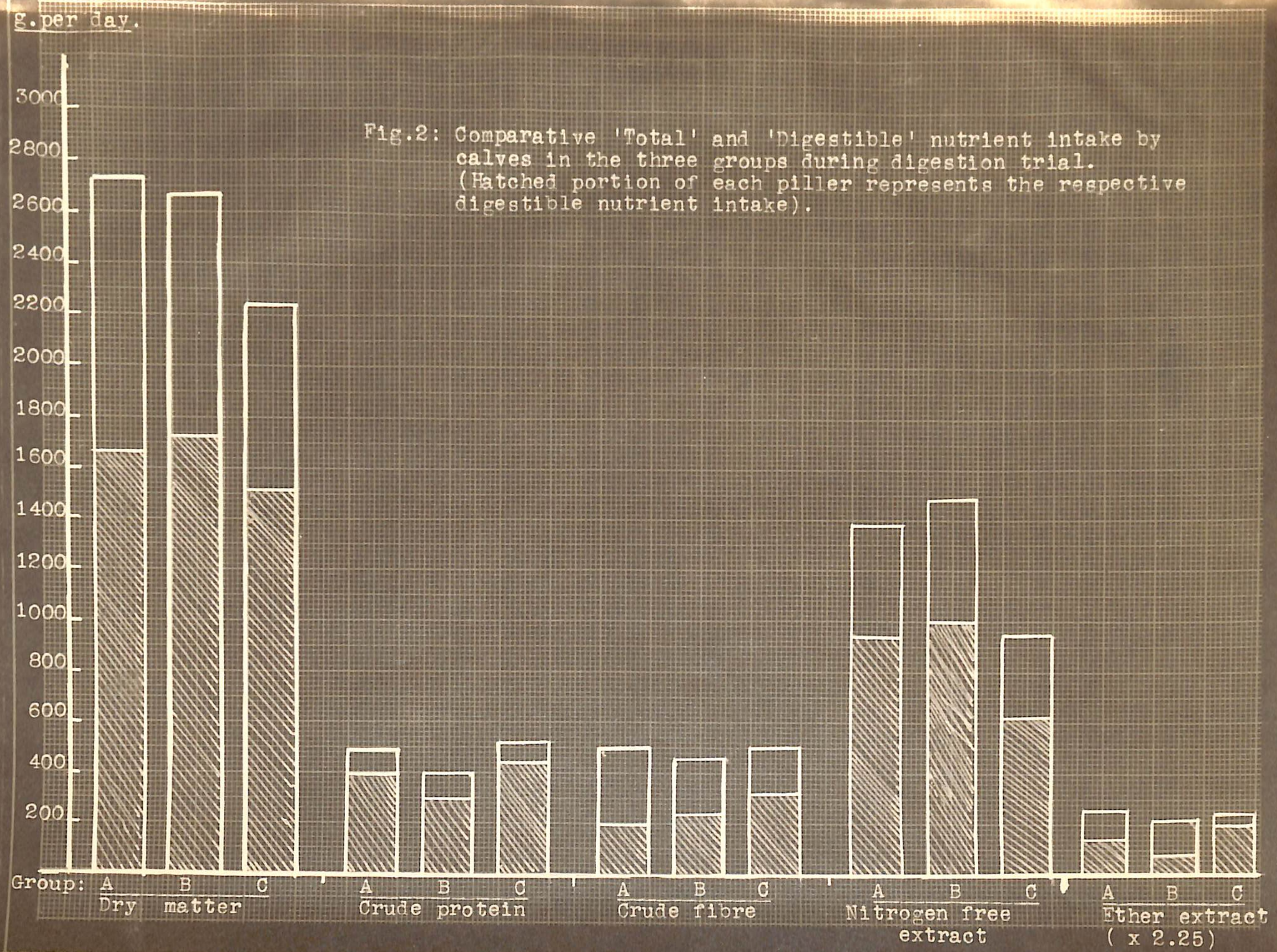


Fig.2: Comparative 'Total' and 'Digestible' nutrient intake by calves in the three groups during digestion trial. (Hatched portion of each piller represents the respective digestible nutrient intake).

The digestibility coefficients for various nutrients obtained from the two animals of the same group are in close agreement. For the purpose of comparison, the averages of the coefficients of duplicates in each group is shown below.

TABLE 4.4D

Average digestible coefficients for various nutrients, group wise (percent)

	D.M.	D.C.P.	C.F.	N.F.E.	Total C.H.O.	E.E.
Group A	61	80	41	67	60	55
" B	65	78	54	69	64	40
" C	67	86	64	66	65	83

As the calves of the three groups were fed with three different concentrate mixtures, it is difficult to compare the values for various nutrients between the groups. First the results of group A, fed at Morrison standards as general guide are taken for comparison with the results of other authors worked with calves of same age, fed on comparable basis.

TABLE 4.4E

Digestion trial data of other workers compared to the results of present study(percent)

Author	D.M.	C.P.	Total C.H.O.	E.E.
Verma (1963): Berseem lot ...	66	78	61	51
" " Concentrate lot	69	76	59	81
Mudgal(1965): First trial ...	60	69	59	65
" " Second trial ...	66	64	66	67
Dalai (1966): Morrison std. group	56	70	59	78
Present study : Group A ...	61	80	60	55

Dry matter:- The digestibility coefficient for dry matter is in good agreement with others.

Crude protein:- The coefficient for crude protein appear to be high than the findings of Mudgal (1965) and Dalai (1966), but comparable to the results of Verma (1963). Verma ascribed the higher coefficients to green Berseem in one group and higher ratio of concentrate mixture to roughage (67:33) in other. The calves of the group A in the present study also received the ration having similar concentrate to roughage ratio (70:30).

Mudgal (loc.cit.) and Dalai (loc.cit.) fed the calves in a relatively higher plane of nutrition. The dry matter intake for their calves were on average 2.1 and 2.8 kg. per 100 kg.body weight per day respectively; whereas in present study the calves were fed on average at 1.6 kg. dry matter per 100 kg. body weight per day.

When the dry matter intake is reduced, correspondingly the metabolic nitrogen out put is also reduced, and the lowered proportion of metabolic nitrogen in the faeces naturally increases the apparent digestibility of food protein, although the true digestibility is not affected. This might be the cause for the increase in apparent digestibility of crude protein in this group.

To estimate the actual differences in true digestibility coefficients for these studies, taking into consideration the differences in metabolic nitrogen content in the faeces, true digestibilities are calculated.

For the purpose of comparison the data obtained by Mudgal (1965) in the two metabolism trials for group B and the present data of group A are used.

	D.M.intake (kg./day)	C.P.intake (g./day)	Apparent digestibility of C.P.(%)
Mudgal(1965) :			
First trial	3.869	430	69
Second trial	4.619	523	64
Present study:Gr.A	2.712	483	80

Assuming that an amount of 0.45 g. of metabolic nitrogen is excreted for each 100 g. of dry matter intake in feed (Blaxter & Mitchell,1948;cited by Lofgreen _et al_.,1951) and 6.25 as factor for converting it into crude protein equivalent, the true digestibility of crude protein is calculated as shown in table 4.5.

The true digestibility coefficients of crude protein are worked out to be 94, 91 and 96% for Mudgal's trials I & II and present study respectively.

The true digestibilities of the three data are in very good agreement.

TABLE 4.5

True digestibility of crude protein in the three data

Sl. No.	Item	Mudgal(1965) Trial I	Mudgal(1965) Trial II	Present study gr.A
1.	Dry matter intake in feed kg./day	3.869	4.619	2.712
2.	Apparent digestibility of crude protein %	69	64	80
3.	Apparent undigestibility of crude protein %	31	36	20
4.	Crude protein intake kg./day	0.430	0.523	0.483
5.	" " excreted kg./day	0.1345	0.1871	0.095
6.	Met.N.excreted X 6.25(Mitchell) (estimated figure) kg./day	0.1088	0.1299	0.076
7.	Undigested C.P.of food origin in faeces (5*-6*)	0.0257	0.0572	0.019
8.	Net digested C.P.from the food (4*-7*)	0.4043	0.4658	0.464
9.	True digestibility (%) ... ($\frac{8^*}{4^*}$ X 100)	94.01 (94)	91.14 (91)	96.07 (96)

* Represents respective item value in the serial number.

Total carbohydrates:- When the total carbohydrates are taken into consideration, the digestible coefficient of present study is in agreement with others' findings already cited. When the coefficient is partitioned between crude fibre and nitrogen free extract, there are much differences, probable causes of which are discussed when differences within the groups are discussed.

Ether extract:- The digestibility coefficient for ether extract is 55%. Again this coefficient appear to be lower than than the findings of Mudgal (1965) and Dalai (1966) and tallying with the Berseem lot of Verma (1963).

While discussing the significance of digestibility coefficient of ether extract, Armsby (1931), in his book "The nutrition of farm animals", wrote that unreabsorbed bile constituents, some of which are ether soluble are excreted alongwith the faeces. As the ether extract content of usual feeding stuffs is small, the interference of these ether soluble constituents of unreabsorbed bile gives relatively large errors in computing the percentage digestibility. He also mentioned that several instances are on record in which the ether extract of the faeces has even exceeded that from feed.

Seshan (1932) and Dasgupta (1943) reported that apparent digestibility of EE of the ration will be lower, if the EE in the feed itself is low. Seshan (loc.cit.) found that the digestibility of 'unsaponifiable matter' component of EE may be even negative and concluded that some of this component, found in faeces is derived from the body, and is not an undigested fraction of ingested substance.

Hardfiel (1960) also encountered the problem of high fat content in the faeces and advocated using fresh faeces hydrolised with hydrochloric acid and dried rapidly for 2 hrs. at 95°C before being extracted in conventional way, to avoid the EE fraction of body origin.

The previous discussion will indicate that high ether extract value in faeces and decreasing digestion coefficient is not uncommon. As Armsby (1930) suggested, the descripancy is relatively of less importance in view of the small role which fat plays in the ordinary rations of farm animals.

Digestion coefficients between groups A,B and C.

The average digestibility coefficients of each group are already presented in table 4.4D.

Dry matter:- The digestible coefficient for dry matter is lowest in group A (61%) and increased to 65% in group B and reached maximum of 67% in group C. Digestion coefficients for crude fibre also followed the same order.

Comparison between groups A & B :- Between groups A and B, dry matter and total digestible nutrients intake was almost the same, but crude protein for group B was about 20% lower. But in the digestibility coefficients, there is marked difference for various nutrients. Most marked difference is with crude fibre. This may be due to lowered protein intake in group B resulting in increased digestion of crude fibre. This is in accordance with the findings of Witczack (1957), who studied the influence of different levels of protein contents of feed on decomposition of fibre in the rumen of sheep and found that the amount of fibre decomposed on diet lower in protein was slightly greater.

In fact, in the present study, in the calves of group

B; only 32 g. more of crude fibre was decomposed per day. The crude fibre content of the entire ration was as low as 18.2% and decomposition of additional 32 g. of crude fibre gave higher digestibility coefficients.

The components crude protein and ether extract recorded low digestibility in group B which should have decreased the value for dry matter digestibility, but their impact is very low because the difference in the percentage digestibility of crude protein is very low and though the difference is high for ether extract, the total amount of ether extract playing the role is very low.

The decreased digestibility coefficient for crude protein for group B might be due to its comparatively wider nutritive ratio (1:4.59) than that for group A (1:3.43). It is an established fact that wider the nutritive ratio, lower the apparent digestibility of crude protein (Maynord,1956) of a ration.

<u>Comparison between groups A and C:-</u> It is noticed that except nitrogen free extract, all other components recorded a high percentage of digestibility for group C. The ration for this group is low in dry matter and energy, but crude protein level is the same. As all the nutrients recorded higher digestibility, a common cause is expected for this rise. The main difference was in their dry matter intake. Whereas group A was fed at 1.84 kg./100 kg.body weight, group C was fed at 1.68 kg./100 kg.body weight. This low level of dry matter intake

would have resulted in higher digestibility of dry matter along with other nutrients. Morrison (1959) mentioned that farm animals usually digest a slightly larger percentage of their feed when fed a scanty ration, than when they receive a full ration. The probable causes leading to higher digestibility of dry matter in group C are given below.

(1) It is reported that the digestibility of crude fibre is generally dependent upon the rate of passage of feed through reticulo-rumen (Balch, 1950; cited by Bhattacharya, 1966-67). Slower the rate more the digestion of crude fibre. Mean retention time of dry matter in reticulo-rumen was found to be significantly negatively correlated with amount of dry matter eaten per 100 kg. body weight by French (1956), Makela (1956) and Paloheimo and Makela (1960). Thus due to decrease in dry matter intake, crude fibre digestion was more in group C than in group A.

(2) Crude fibre in the ration tends to exert a protective influence against digestion of all nutrients (Maynord, 1956). Increased digestion of crude fibre indirectly facilitated the digestion of other nutrients.

(3) Decreased food residues might have decreased the rate of flow of digesta through lower gut and improved the absorption of nutrients from the lumen.

Digestibility coefficient for crude protein was 86% for group C, whereas for group A, it was only 80%. The narrower nutritive ratio of the ration of the group C (1:2.85) than that of A (1:3.43) and the reduced metabolic nitrogen excretion due to decreased dry matter intake, might have caused the increase in apparent digestibility of crude protein in the group C.

To determine the extent, this decreased metabolic nitrogen has influenced the apparent digestibility, the true digestibility of crude protein is calculated on the same lines described earlier.

Average D.M. intake	:	kg./day	=	2.241
Metabolic-N x 6.25 for this dry matter intake	:	g./day	=	63
Faecal crude protein excretion	:	g./day	=	70
Faecal crude protein of food origin	:	g./day	=	7
Total C.P. intake	:	g./day	=	512
Net C.P. absorbed	:	g./day	=	505
True digestibility of C.P. (%)		$= \frac{505}{512} \times 100$	=	98.1

The true digestibility of crude protein in group C is 98.1% and in group A 96.07%. Thus the increase of 2% digestibility may be attributed to the narrow nutritive ratio of the ration for group C.

Nitrogen free extract:- Contrary to all other nutrients, N.F.E. has recorded lowest digestibility in group C. The increased crude fibre digestion indirectly lowered the digestibility coefficient of N.F.E. Undigested residues of crude fibre component might have been sufficiently broken down to appear in N.F.E. of faeces instead of in the crude fibre portion (Maynord,1957) and would have given lower value.

Ether extract:- The higher digestion coefficient for ether extract for this group might be due to improved resorption of constituents of bile. The energy intake for this group is low. Under this stress, the system would have been so adjusted to check the wastage of energy and conserve as much as possible by way of reabsorption of the bile constituents along with other measures. This type of economy usually takes place with constituents like water, ions of sodium, potassium etc., but no specific instance on record is available in support of this view, except from the works of Sharma and Talapatra (1963), who obtained digestibility coefficients of EE 61.64% in high-plane group and 74.37% in low-plane groups.

(b) Estimation of dry faeces out put by chromic oxide indicator technique:- During digestion trial, daily grab samples of faeces were collected from each calf at 6 a.m. and 4 p.m., dried in hot air oven and bulked. The bulked samples for 8 days were powdered and mixed well before the chromic oxide content was estimated as described in the chapter "Materials and Methods".

From the percent of indicator in faeces, the excretion of dry faeces by each calf was estimated. Taking the values of dry matter excreted, obtained by total collection method and concentration of indicator by grab sample technique, average recovery of the indicator was calculated.

As an example, calculations in detail for the calf no.156/65 of group A is given below:-

		(a)	(b)
Dry faeces ashed	---	5 g.	5 g.
Std. Fe^{++} (N/12) solution added after perchloric acid digestion		20 cc.	20 cc.
Std.pot.permanganate (N/9.5) back titrated with excess Fe^{++}		2.6 cc.	2.4 cc.
Average	---	2.5 cc.	
" in terms of (N/12)		3.2 cc.	
N/12 Fe^{++} titrated with $Cr_2O_7^{--}$		20-3.2 = 16.8 cc.	

$$\% \; Cr_2O_3 \text{ in faeces} = \frac{V \times N \times \frac{152.02}{6000} \times 100}{\text{Sample weight}}$$

Where V is the volume of std. Fe^{++} titrated

N is the normality of Fe^{++} solution used

$$= \frac{16.8 \times \frac{1}{12} \times \frac{152.02}{6000} \times 100}{5}$$

$$= 0.7092 \text{ ----------------- (I)}$$

$$\text{Average dry faeces excreted by the calf (g./day)} = \frac{\text{Quantity of indicator fed}}{\% \text{ indicator in faeces.}} \times 100$$

$$= \frac{9.41 \times 100}{0.7092} = 1326 \text{ --- (II)}$$

% of recovery of chromic oxide from grab sample:

Average dry matter out put in faeces as found by total collection method = 1025 g./day

Amount of chromic oxide fed = 9.41 g./day

Concentration of chromic oxide in faeces (T.above) = 0.7092 %

Total chromic oxide recovered daily as per grab sample concentration = $\frac{1025 \times 0.7092}{100}$

% recovery of Cr_2O_3 = $\frac{1025 \times 0.7092}{100} \times \frac{100}{9.41}$

= 77.25 ---------------(III)

The values in respect of other calves also are calculated and incorporated in table 4.6.

TABLE 4.6

Estimates of dry faeces excretion and recovery of indicator by grab-sample method.

Group	Calf No.	Dry faeces out put (total collection; g./day)	% indicator in grab samples	Estimated D.M. out put by grab sample method.	% recovery of Cr_2O_3
A	156	1025	0.7092	1326	77.25
	19	1075	0.6375	1472	77.83
B	39	876	0.8563	1099	79.71
	46	991	0.7954	1183	83.77
C	162	709	0.9576	983	72.15
	11	729	0.9221	1021	71.44

In all observations, the estimated dry matter excretion by grab sample method is considerably more than the values obtained by total collection method. This high estimate is due to low recovery of indicator in grab-samples.

Among various works with chromic oxide as indicator for digestibility trials reviewed in chapter "Review of Literature", only few authors reported erratic results by this method.

Hardison and Co-workers (1959) in three digestion trials obtained low recovery of chromic oxide both from totally collected faeces and grab samples. The mean recovery of indicator from totally collected faeces was 89.4 to 97.5% and from grab samples 89.7 to 96.4 %. They estimated the average daily faecal dry matter outgo from grab sample technique with an error of about 14%.

Clanton <u>et al</u>. (1962) reported 95.1% recovery of chromic oxide in total collections and still lower recovery from grab sample technique.

Deinum <u>et al</u>. (1962) found traces of the indicator in internal organs like liver, lymph glands and kidneys. He attributed the absorption of chromic oxide from alimentary canal as the preliminary cause for low recovery.

In present study, it was presumed that the grab samples obtained at 6 a.m. and 4 p.m. gives 100% recovery of the indicator. Kameoka and Co-workers (1956), Balch <u>et al</u>. (1957), Putnam <u>et al</u>. (1958), Hardison and Co-workers (1959), Corbett <u>et al</u>. (1960), Linnerud and Donker (1961) and Majumdar and Gupta (1962) reported that the inherent periodicity in the chromic oxide excretion pattern is not uniform and is easily altered due to factors like time and method of administration of indicator, type of feed offered and other feeding and management practices.

The survey of Putnam (1962) revealed that 56 laboratories out of 101 from whom reports were received used chromic oxide in digestion trials and among them 26 laboratories obtained abnormal results at one time or other.

The concentration of chromic oxide in the grab sample of faeces collected at different times of a day, is reported to have a wide range. According to Hardison (1953) the concentration ranged from 72.8 to 129.3% of the mean values for the 24 hrs. Smith and Reid (1955) and Putnam (1958) reported the range to be 65 to 141% and 80 to 120% respectively.

The rational method would have been to study the chromic oxide excretion pattern and select the times of grab-sampling to ensure 100% recovery of the indicator.

Another flaw in the present study is that the chromic oxide used was a laboratory grade having 78.4 % chromic oxide equivalent. This value was obtained when estimated after prolonged digestion in oxiding mixture and recovered after adding known quantity of the indicator in dry powdered faeces.

The sample is found to contain 17% water soluble impurities, of which 1% was dichromates and readily reduced by ferrous ammonium sulphate. The insoluble chromic oxide left after washing with distilled water, when suspended in 3% hydrochloric acid, produced a light green solution suggesting the presence of acid soluble chromium salts as well, which can not be estimated by standard iron solution.

These impurities, namely dichromates and other acid soluble chromium salts were included in the recovery value of chromic oxide in the original samples, but in alimentary tract these soluble components might have been absorbed giving low recovery in faeces.

If the recovery of chromic oxide from the totally collected faeces was also estimated, it would have been easier to conclude whether low recovery was due to either absorption or variation in chromic oxide excretion pattern. This could not be done due to exhaustion of perchloric acid, which could not be procured from the markets.

As the estimates of dry matter out-put is considerably higher by grab sample, technique than by total collections, digestion coefficients will be lower if calculated by the former method. Hence digestion coefficients of various nutrients were not calculated by the indicator method.

(ii) Nitrogen balance trial:

The details of urine collection and nitrogen content of pooled urine is given in table 4.7. Considering the daily nitrogen intake, and nitrogen excretions in dung and urine, balance for each calf is reckoned and presented in table 4.8. The effect of energy intake on nitrogen retention is presented in table 4.9.

TABLE 4.7

Daily collections of urine during metabolism trial(in litre)

Sl.No.	Group A		Group B		Group C	
	Calf no.					
	156/65	19/66	39/66	46/66	162/65	11/66
1.	3.630	6.050	4.760	4.590	4.810	3.715
2.	3.230	2.945	4.900	4.985	5.590	3.735
3.	2.785	3.405	5.395	3.730	5.130	4.470
4.	5.970	3.620	5.245	6.185	7.455	5.555
5.	4.935	4.480	3.820	4.220	5.715	5.390
6.	4.620	3.520	5.230	4.715	5.400	4.980
7.	5.230	4.350	4.265	4.070	6.340	4.825
8.	4.665	3.735	5.045	4.540	5.930	5.180
Average	4.383 ±.377	4.013 ±.337	4.820 ±.179	4.629 ±.255	5.796 ±.285	4.731 ±.242
N-content g./litre	10.42	11.12	8.28	8.64	9.60	11.30
Total urinary N.[g. per day.]	45.58	44.63	39.91	39.98	55.65	53.47

TABLE 4.8

Nitrogen balance data

Group	Calf No.	Total C.P. intake g./day	Nitrogen intake g./day	Nitrogen outgo g./day			Nitrogen balance g./day.
				Faeces	Urine	Total	
A	156	483	77.27	15.20	45.58	60.78	+16.49
	19	483	77.27	14.72	44.63	59.35	+17.92
Average		483	77.27	14.96	45.10	60.06	+17.20
B	39	390	62.40	13.12	39.91	53.03	+9. 37
	46	398	63.68	15.20	39.98	55.18	+ 8.50
Average		394	63.04	14.16	39.94	55.10	+ 8.93
C	162	512	81.93	11.04	55.65	66.69	+15.24
	11	512	81.93	11.04	53.47	64.51	+17.42
Average		512	81.93	11.04	51.56	65.60	+16.33

TABLE 4.9

The effect of energy intake on nitrogen retention

Particulars	High energy		Low energy; high protein Gr.C
	High protein Gr.A	Low protein Gr.B	
Nitrogen consumed g./day ...	77.27	63.01	81.93
Nitrogen apparently digested g./day	62.36	48.88	70.89
N. apparently digested above maintenance needs g./day	41.93	28.45	50.46
Non-nitrogenous TDN consumed g./day	1286	1344	1148
Nitrogen retained g./day ...	+17.20	+8.93	+16.33
Nitrogen retained(% of consumed N)	22.25	14.18	19.93
N-retained (% of apparently digested above maintenance needs)	41.02	31.39	32.37
Efficiency of retained nitrogen g.N-retained/1 kg. of growth	41.95	22.41	54.80

N. apparently digested above maintenance needs is calculated as follows:-

The average body weight of calves taken for metabolism trial was 166 kg.(365 lb.). Maintenance requirement of nitrogen for cattle is 43.5 g.(0.6 lb.DCP) per 1000lb.body wt. (Lofgreen *et al.*,1951) and requirement is presumed to vary with the 0.75 power of the body weight($W^{.75}$).

Maintenance requirement for animal weighing 365 lb. =

$$\frac{43.5 \times (365)^{.75}}{(1000)^{.75}} \text{ g./ day}$$

$$= \text{Antilog}\left[\log 43.5 + \tfrac{3}{4} (\log 365) - \tfrac{3}{4} (\log 1000)\right] \text{ g./day}$$

= 20.43 g. of Nitrogen per day.

Nitrogen apparently digested above maintenance needs = Apparently digested nitrogen - maintenance requirement.

All the calves of metabolism trial were having positive N-balance, ranging from 8.5 to 17.42 g./day. There is good agreement for the values between the animals of the same group.

Group B versus group A:- Average nitrogen intake of group B was 14.23 g. less than that of group A. But in final balance, it is less by only 8.27 g. B group seems to have conserved more nitrogen by reduced N-excretion through dung and urine; a reduction of 0.8 g. in faeces and of 5.16 g. in urine making a total of 5.96 g. This fact is borne by the observations of Schmidt - Nielson (1964) (cited by Taneja, 1966-67) in camel. It is reported that during stressful conditions of low protein intake, the urea concentration in the urine of this species may go as low as its concentration in the blood itself. It is presumed that urea instead of being excreted by the kidney, enters the rumen via the saliva in increased amount than normal, where the bacteria use it in the synthesis of proteins.

Group C versus group A:- Animals of group C had consumed 4.66 g. more of nitrogen in the ration than that of group B, but in nitrogen balance it is less by 0.87 g. In nitrogen excretion, group C excreted 3.92 g. less in faeces but 9.46 g. more in urine. This resultant increased nitrogen excretion lowered the nitrogen balance of this group.

It is evident that the liberal supply of energy to group B resulted in considerable amount of protein sparing effect, but in group C much of the absorbed protein is deaminated for supply of energy and the nitrogen component is lost to the animal as urinary nitrogen excretion.

Percent retention of nitrogen of apparently digested and surplus over maintenance requirement was high in group A (41.02%) and equally low in both the groups B (31.39%) and C (32.37%).

From the nitrogen balance data presented in table 4.8, it appears that group B has least chance of growth in weight due to its lowest nitrogen balance than the other groups. But the growth rate in this group is as good as for group A, a nominal difference of 13 g./day which is found to be statistically insignificant. Contrasting to this, group C, though they are having as high nitrogen balance as group A, their growth rate on average was only 298 g./day; a difference of 103 g./day and the difference is highly significant.

Thus it appears that only from nitrogen balance studies, it is difficult to guess the growth in weight of any animal. In support of this point, some of the published metabolism trial data are given in table 4.10.

TABLE 4.10

Comparison of studies on nitrogen balance and growth in animals.

Author	Short description of work		N-balance g./day	Growth g./day
Cunningham (1960)	Studies on pigs with different levels of protein but energy at 33 Kcal/kg. body weight.			
		16% crude protein level	2.57	1000
		26% " "	4.76	-29
		33% " "	5.74	14
Ranjhan and Talapatra (1963)	Hariana calves :	Berseem group	18.80	328
		Berseem, bone meal group	30.10	400
		Berseem, wheat bran group	18.80	431
Sharma and Talapatra (1963)	Murrah calves :	High plane	37.50	630
		Medium plane	12.69	446
		Low plane	4.86	---*
Mudgal and Ray (1965)	Sahiwal calves :			
	Ist trial	A. 20% more C.P.	13.62	416
		B. Morrison std.	11.08	393
		C. 20% less C.P.	8.40	416
	IInd trial	A. 20% more C.P.	22.08	416
		B. Morrison std.	19.48	393
		C. 20% less C.P.	12.15	416

* Older calves lost weight, young calves maintained.

Whether the nitrogen balance is commensurate with growth in calves of respective groups ?

According to Maynord (1956), the average composition of steer excluding contents of digestive tract is : Water 54%, protein 15%, fat 26% and mineral matter 4.6%. Assuming that newly formed tissues in growing calves has the same composition, and that protein contents 16% nitrogen, each 100 g. growth would retain approximately 2.4 g. of nitrogen. Thus group A which had average growth rate of 411 g./day should have a minimum N-balance of about 9.6 g./day, whereas it showed a positive balance of 17.2 g./day, an excess of 7.6 g./day over and above the minimum requirement for growth. Group B having almost the same growth rate, was having just 8.93 g.N-balance, barely sufficient for growth.

Group C had growth rate of 298 g./day on average and a nitrogen balance of 7.2 g./day would have been sufficient, but it was having a balance of 16.33 g./day, a surplus of 9.13 grams per day.

Thus it appears that calves of groups A and C were putting on tissues with higher proportion of protein than those of group B.

It is known that liberal protein intake results in a small increase in body, referred as 'protein reserve' (Maynord,1956). The existence of this protein reserve will be known in nitrogen balance studies.

Existence of 'protein reserves' and their response to protein feeding were reported by Lofgreen <u>et al</u>.(1951) in calves, Lagrutta and Cilento (1954) in rats, Jacobus <u>et al</u>.(1965) in cocks and Gopalan and Narasingarao (1966) in human subjects.

III. Feeding trial:

As explained in the chapter "Materials and Methods" the animals of three groups were fed with three different concentrate mixtures and green Paragrass in quantities shown in table 4.11.

TABLE 4.11

Quantities of feeds offered to calves
(kg./day)

Particulars	Group A	Group B	Group C
Concentrate mixture:			
I & II Fortnights	1.80	1.80	1.10
III & IV "	1.90	1.90	1.20
V & VI "	2.00	2.00	1.30
VII & VIII "	2.10	2.10	1.40
Green Paragrass :			
I to VIII Fortnights	4.00	4.00	5.00

All the calves in group C used to take their concentrate mixture very slowly. At times some used to leave small quantities of concentrate mixture even for 3 hrs.after offering the feed. Small quantity from their roughage ration used to be well mixed with the left overs, and only after consuming them remaining ration used to be offered.

Dry matter consumption:- The average dry matter consumption of all animals of each group during the period of experiment is given in table 4.12.

The dry matter consumption per 100 kg. body weight is less in second half of the experiment than in the first half. The dry matter content of Paragrass which was 23.0 to 32.05 % in first two months dropped down to 17.5 to 18.2% in

TABLE 4.12

Average fortnightly dry matter consumption of experimental calves(kg.).

Fort-night	Average body weight	Av.fortnightly D.M.consumption/calf			D.M. per calf per day	D.M. intake per 100 kg. body wt./day
		Concentrate.	Roughage.	Total		
1	2	3	4	5	6	7
			Group A			
I	124	23.52	13.80	37.32	2.488	2.006
II	131	23.52	18.90	42.42	2.828	2.158
III	137	24.62	19.01	43.63	2.908	2.122
IV	142	25.14	14.64	39.78	2.652	1.867
V	147	27.00	10.62	37.62	2.508	1.706
VI	154	27.00	10.50	37.50	2.500	1.623
VII	161	28.62	10.98	39.60	2.640	1.639
VIII	168	28.62	10.91	39.51	2.634	1.567
					Average ...	1.84 ± .022
			Group B			
I	120	23.52	13.50	37.02	2.468	2.146
II	127	23.52	18.90	42.42	2.828	2.337
III	132	25.14	19.44	44.58	2.972	2.358
IV	139	25.14	14.64	39.78	2.652	1.979
V	145	27.00	10.62	37.62	2.508	1.791
VI	151	27.00	10.60	37.60	2.506	1.716
VII	156	28.62	10.85	39.47	2.631	1.719
VIII	162	28.62	10.87	39.49	2.632	1.648
					Average ...	1.91 + .020

TABLE 4.12 (contd.)

1	2	3	4	5	6	7
			Group C			
I	115	13.50	17.25	30.75	2.050	1.782
II	121	13.50	23.62	37.12	2.407	1.989
III	125	15.12	24.37	39.49	2.632	2.105
IV	129	15.12	18.30	33.42	2.228	1.727
V	134	16.87	13.27	30.14	2.093	1.561
VI	138	16.31	13.05	29.36	1.951	1.413
VII	142	18.49	13.72	32.27	2.151	1.514
VIII	147	18.49	13.65	32.14	2.148	1.457
					Average...	1.68 ± .016

last two months.

Paragrass was fed to the calves at a flat rate of 4 kg. for groups A & B and 5 kg. for group C on green basis for each calf every day, irrespective of its dry matter content. This is the main cause for reduction in dry matter intake during the second half of the experiment.

Average dry matter intake for calves in each group for the entire period of experiment worked out to be 1.84 ± .022, 1.91 ± .020 and 1.68 ± .016 kg. per 100 kg. body weight for groups A, B and C respectively. The average weight of the calves of all groups during the experimental period was about 140 kg.

Morrison's minimum recommendation for the growing calves of this weight group is 3.178 kg. which works out to 2.27 kg./ 100 kg. body weight. Thus the actual level of feeding was lower than the recommended level.

This lower level of feeding did not give any adverse result. Few experiments were done in India at lower level of dry matter intake and some of them are cited below.

(Cited by Mudgal, 1966-67)

Breed	Body wt. (kg.)	Description of ration	D.M.intake/ 100kg/body wt.(kg.)
Sahiwal	190	Wheat straw, oat silage, barley, G.N.cake, wheat bran.	2.02
Hariana	164	Wheat straw + Berseem, concentrate mixture	2.03
Tharparkar	326	Wheat straw + G.N.cake	1.33
"	320	" "	1.56
"	185	" "	1.93
Murrah	236	" "	1.96

Nutrients consumption:- Amounts of various nutrients consumed by each group are presented in tables 4.13A, B & C. The digestion coefficients obtained in our digestion trial are presumed to hold good throughout the period of experiment and the quantities of various digestible nutrients consumed are calculated on that basis.

Estimated net energy is calculated by converting starch equivalents into Therms. As an example, nutrients intake data of group A is taken : This group consumed total nutrients, 173.62, 92.92, 436.78 and 28.77 kg. digestible crude protein, digestible crude fibre, digestible nitrogen free extract and digestible ether extract respectively. The total amount of crude fibre in the ration was 226.57 kg.

The estimated net energy is calculated as follows, using the net energy values of Blaxter (1956):-

	Therms	Therms
From dig.crude protein ...	173.62 x 2.24	= 388.91
dig.crude fibre ...	92.94 x 2.36	= 219.34
dig.nitrogen free extract	436.78 x 2.36	=1030.80
dig. ether extract...	28.77 x 5.31	= 152.77
	Total	1791.82
Less losses due to crude fibre in feed (work of digestion) :	226.57 x 1.36	= 308.13
Estimated net energy from the total ration intake		1483.69

TABLE 4.13A

Consolidated statement of nutrients consumption by all calves of Group A(kg.)

Particulars	Fort-night	D.M.	C.P.	Carbohydrate		E.E.
				C.F.	N.F.E.	
Green Paragrass	I	55.20	6.291	17.060	25.00	1.104
" "	II	75.60	6.198	23.360	36.59	1.512
" "	III	76.05	2.662	24.110	39.87	1.521
" "	IV	58.06	3.865	18.570	29.34	1.171
" "	V	42.48	6.500	11.970	20.26	0.850
" "	VI	42.00	5.124	11.840	21.33	0.840
" "	VII	43.92	4.480	15.900	19.76	0.878
" "	VIII	43.63	4.102	15.800	19.98	0.873
Total for fortnights I to VIII		437.44	39.222	138.610	212.13	8.749
Total concentrate mixture for fortnights I to VIII.		836.20	177.800	87.960	439.80	43.57
Grand total	...	1273.64	217.022	226.570	651.93	52.32
Average digestibility coefficient%			80	41	67	55
Digestible nutrients consumed.			173.62	92.937	436.78	28.77

Total consumption of 4 calves in the group for 120 days

Digestible crude protein ... 173.62 kg.

Total digestible nutrients 768.08 kg.

Estimated net energy ... 1483.69 Therm

TABLE 4.13B

Consolidated statement of nutrients consumption by all calves of Group B(kg.)

Particulars	Fort-night	D.M.	C.P.	Carbohydrate C.F.	Carbohydrate N.F.E.	E.E.
Green Paragrass	I	54.00	6.156	16.69	24.46	1.080
" "	II	75.60	6.198	23.36	36.59	1.512
" "	III	77.76	2.721	24.60	41.36	1.555
" "	IV	58.56	3.865	18.57	29.34	1.171
" "	V	42.48	6.500	11.97	20.26	0.850
" "	VI	42.00	5.124	11.84	21.33	0.840
" "	VII	43.39	4.426	15.70	19.53	0.868
" "	VIII	43.48	4.087	15.74	19.92	0.870
Total for fortnights I to VIII		437.27	39.077	138.47	212.79	8.746
Total concentrate mixture for fortnights I to VIII		835.20	142.400	87.30	491.40	39.000
Grand total		1272.47	181.477	225.77	704.19	47.746
Average digestibility coefficient %		-	78	54	69	40
Digestible nutrients consumed			141.550	121.91	485.89	19.100

Total consumption of 4 calves in the group for 120 days

Digestible crude protein ... 141.55 kg.

Total digestible nutrients . 792.32 kg.

Estimated net energy ... 1548.22 Therm.

TABLE 4.13C

Consolidated statement of nutrients consumption by all calves of Group C(kg.)

Particulars	Fortnight	D.M.	C.P.	Carbohydrate C.F.	N.F.E.	E.E.
Green Paragrass	I	69.00	7.847	21.32	30.47	1.380
" "	II	94.48	7.749	29.20	45.73	1.890
" "	III	97.48	3.413	30.91	51.87	1.950
" "	IV	73.20	4.831	23.20	36.67	1.464
" "	V	53.08	8.121	14.96	25.31	1.059
" "	VI	52.21	6.433	14.72	24.53	1.044
" "	VII	54.88	5.598	19.86	24.69	1.097
" "	VIII	54.60	5.133	19.76	25.01	1.091
Total for fortnights I to VIII		548.93	49.125	173.93	264.28	10.975
Total concentrate mixture for fortnights I to VIII.		505.20	171.000	57.76	194.20	36.810
Grand total		1054.13	220.125	231.69	458.48	47.785
Average digestibility co-efficient %		-	86.	64	66	85
Digestible nutrients consumed.-			189.30	148.27	302.61	39.662

Total consumption of 4 calves in the group for 120 days

Digestible crude protein ... 189.30 kg.

Total digestible nutrients .. 729.42 kg.

Estimated net energy ...1383.08 Therm.

TABLE 4.14

Daily average consumption of nutrients per calf

Particulars	Groups A	Groups B	Groups C
Mean body weight (kg.) ...	156	144	133
Dry matter intake (kg.) ...	2.653	2.650	2.196
Crude protein intake (g.) ...	452	378	458
Digestible crude protein intake (g.)	361	295	394
Total digestible nutrients (kg.)	1.600	1.650	1.520
Estimated net energy intake (Therm)	3.092	3.226	2.871

The object of our experiment was to feed the animals of group A with TDN and DCP levels at Morrison's standard, group B with 20% less DCP, but equal TDN as group A; and group C with DCP same as group A but TDN 20% less that group A. As the animals were not consuming the required bulk to give the desired TDN, the ration of the control group (A) was fixed at their maximum feeding at the start of the experiment.

When the actual average daily nutrients consumption by animals of each group is considered (4.14 table), it is found that calves of group A consumed DCP at Morrison's average figures, and TDN only 2/3 of Morrison minimum. Group B consumed DCP 81.7% that of group A and TDN slightly more than group A. Group C consumed DCP at Morrison's average but slightly more than what group A consumed and TDN slightly less that group A (94.9% of group A).

Though calves of group A & B were fed at same energy level, due to higher digestion coefficient for carbohydrates, group B is found to have consumed more total digestible nutrients. Calves of group C consumed dry matter 82.8% of group A, and the roughage to concentrate ratio is more but due to significant increases in digestibility coefficients, their total digestible nutrient consumption was actually nearly equal to group A.

<u>Digestible crude protein</u>:- While suggesting maximum and minimum standards for DCP for farm animals, Morrison (1959) recommended to use minimum standards when protein rich feeds are costly and to supply enough proteins to reach towards higher figure in the standard when the protein rich feeds are cheaper. Lofgreen <u>et al</u>.(1951b) after discussing theoretical requirement of growing heifers, suggested an allowance of 340 g. of DCP/day to the calves weighing about 160 kg.

Considering these, the DCP allowance to group A is fairly liberal but not too much.

<u>Total digestible nutrients</u>:- TDN values recommended by Morrison (1959) for the calves of same weight group, are 2.43 kg. minimum and 2.86 kg. maximum. These recommendations provide a reasonable margin of safety and aimed for calves growing at about 700 g./day.

Indian cattle are generally regarded to have lower metabolic rate at about 20% less that the values reported for

European cattle (Kehar,1952) and the growth rate of calves of present study was only 411 g./day.

Sen (1953) considering the reported endogenous urinary nitrogen excretion of Indian cattle, worked out the basal metabolism to be 4.5 Therms per day/1000 lb., increasing the value by 25% to cover the activity increment, he concluded that the maintenance requirement of Indian cattle to be 5.6 Therms/1000 lb. body weight. Taking Sen's values into consideration and changing the requirement in proportion to the weight to the power 3/4 ($W^{\frac{3}{4}}$), the approximate maintenance requirement of experimental calves in present study would be 2.512 Therms/day, whereas calves of group A were getting 3.092 Therms/day. For wintering beef calves of 350 lb./body weight, and growing at 337 g. to 450 g./day, Morrison recommended an energy supply of 3.6 Therms/day.

Sen's earlier recommendations for Indian growing cattle of 157 kg. body weight ranged between 2.58 kg./day for class I to 1.305 kg./day for class III, depending upon mature body weight of the breed.

Inspite of slightly lower level of TDN intake, compared to Morrison's standard, calves in all the groups showed sufficient growth all along the experimental period at that level of feeding. Some of the experiments done in India, feeding calves on relatively low energy are given below.

Ranjhan and Talapatra (1963) reported feeding of Hariana calves of 147 kg.body weight and growing at 328 g./day with 1.75 kg. of TDN per day from berseem and wheat straw and for calves weighing 170 kg., growing at 431 g./day with 1.967 kg. of TDN per day from berseem, wheat straw and wheat bran.

Verma (1963) fed Tharparkar calves of about 150 kg. body weight, growing at 580 g./day with 1.96 kg./day.

From the above discussion, it can be concluded that though the calves were fed at relatively low plane, it is sufficient for the maintenance and reasonable growth of the calves.

IV. Growth rate:

Growth in body weight:

The details of weighing were described in chapter "Materials and Methods". The fortnightly growth in weight of the calves are presented in table 4.15 and represented in figure 1.

The growth data was statistically analysed for variance and the result is presented in table 4.16.

The growth rate (kg./fortnight) of individual calf ranged between 5.750 ± .452 to 6.500 ± .286 in group A, 5.750 ± .639 to 6.375 ± .350 in group B and 4.250 ± .589 to 4.750 ± .535 in group C. Standard error is ranging between ± .286 for 161/65 to ± .639 kg. for 39/66, which appear to be very high. But when the pooled performance of all the four calves in each group is compared, the S.E. has dropped down to ± .254, ± .250 and ± .219 kg. for groups A, B and C respectively.

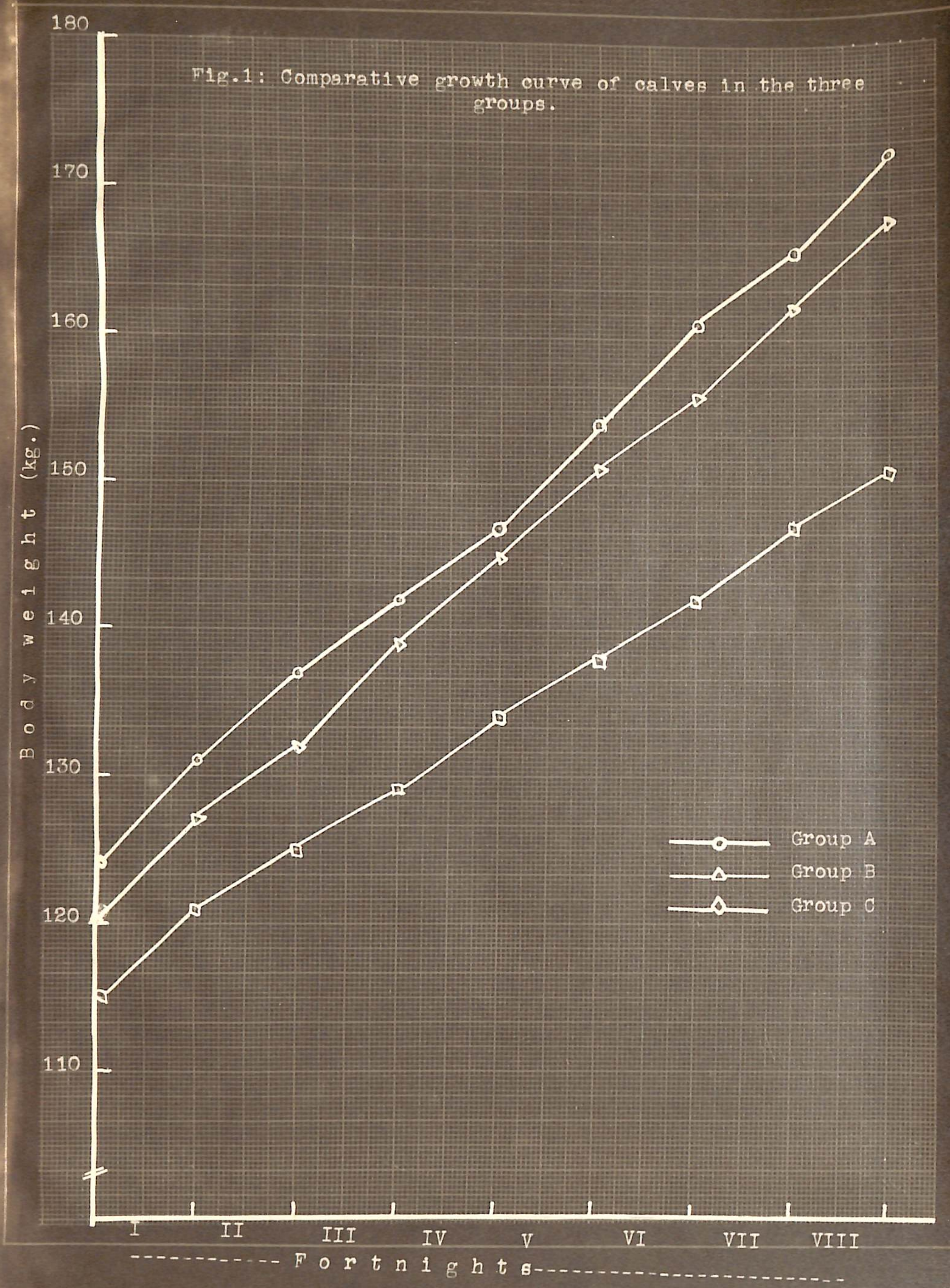


Fig.1: Comparative growth curve of calves in the three groups.
Body weight (kg.)
180
170
160
150
140
130
120
110
Group A
Group B
Group C
I
II
III
IV
V
VI
VII
VIII
Fortnights

TABLE 4.15

Fortnightly growth of calves(kg.)

Fortnight	Group A				Group B				Group C			
	Calf nos.				Calf nos.				Calf nos.			
	156	161	19	72	155	159	39	46	162	8	11	74
I	6	6	9	8	6	8	8	6	6	5	6	6
II	6	7	4	6	6	4	5	5	5	6	4	4
III	4	6	5	6	6	5	8	8	3	2	5	6
IV	5	6	6	5	6	8	6	6	6	3	3	5
V	6	7	7	6	8	4	6	6	3	6	4	6
VI	8	6	7	6	5	6	3	7	4	3	5	4
VII	6	8	6	8	5	6	5	7	4	6	4	5
VIII	5	6	5	6	6	6	5	6	5	4	4	2
Average(kg.)	5.750 ±.452	6.500 ±.256	6.125 ±.589	6.250 ±.452	5.875 ±.378	5.875 ±.589	5.750 ±.639	6.375 ±.350	4.500 ±.452	4.250 ±.589	4.375 ±.350	4.750 ±.535
Av.for group (per fortnight)	6.163 ± 0.254				5.969 ± 0.250				4.468 ± 0.219			
Av.daily gain (g./day).	411				398				298			

TABLE 4.16

Analysis of variance for the growth in weight in the groups.

Source of variance	D.F.	S.S.	M.S.	F.Value	Remarks
Between groups	2	53.90	26.950	20.859	**
Between fortnights	7	24.00	3.428	2.653	*
Group X Fortnight	14	22.75	1.628	1.260	
Error	72	93.35	1.292	-	
Total	95	-	-	-	

** Highly significant(P∠01); * Significant (P ∠ 05).

Critical difference between groups P 01 Df 72 = 0.752.

Difference between groups : A & B ... 0.194 insignificant

A & C ... 1.695 highly significant

B & C ... 1.501 highly significant

Critical difference between fortnights P 05 Df 72 = 0.935

Bar diagram of average fortnight weights and their corresponding fortnight in increasing order:-

Fortnight	VIII	II	III & VI	IV	V	VII	I
Average growth.	4.917	5.083	5.333	5.417	5.667	5.883	6.667

The average growth rate is 411, 398 and 298 g./day per calf for groups A,B and C respectively. The analysis of variance reveals that the growth rate of calves in group C is significantly different (P∠ 01) to that of calves in group A and B, but the growth rates of calves in groups A and B do not differ significantly.

Feeding of calves (group B) with about 20% less crude protein than Morrison's standard, gave equally good response in growth which is in agreement with the findings of Lofgreen et al.(1951b), Sharma (1962)and Mudgal and Ray (1964b).

Clanton et al.(1964) reported that there was difference in growth rate when protein in the ration is reduced. Beef heifers when fed according to N.R.C. recommendations, grew at 0.81 lb./day, but when the protein intake was reduced to 60%, maintaining the energy intake, the growth rate diminished to 0.44 lb./day.

Correl et al.(1964) studied the energy utilisation of heifers at different levels of protein intake in rations that were iso caloric. They recorded a total growth of 0.6 lb. in low protein group fed with crude protein at 2.7% level in the ration and 27 lb. in control group fed at 12.5% crude protein level, during a 110 days' study period.

Our results are, however, not strictly comparable to their's specially in the extent of reduction in protein intake of the groups. Clanton et al.(1964) fed the low protein group at 60% of control and Correl et al.(1964) fed at 2.7% C.P.level against control at 12.5%. There were drastic differences in the protein intake between the groups. The low protein group might be getting very little protein over and above the maintenance requirement, resulting in poor response in the growth.

Decrease in TDN intake (group C) resulted in highly significant low growth rate, which is in agreement with the findings of Winchester et al.(1956), MacDonald (1957), Hendrickson et al.(1961) and Clanton (1964).

When the average fortnightly growth rates of all calves are compared, I fortnight recorded significantly high growth than other fortnights except VII, and fortnight VII recorded significantly higher growth rate than fortnight VIII. The growth during other fortnights are not different from one another significantly. There is no specific reason to attribute for these differences.

The growth recorded for the calves of same age group and breed, in this farm by previous workers,is 590 g./day for the control which received concentrates and roughages in the ratio of 3:1, 396 g./day in "All Berseem ration" groups by Verma (1963), 359 g./day by Dalai(1966), in control group (Morrison's standard).

Under existing farm conditions, the growth in Tharparkar calves in National Dairy Research Institute, Karnal, is reported to be 383 g./day (Mudgal and Ray,1965a).

This finding shows that for obtaining proper growth, adequate energy intake has to be ensured. Level of crude protein in the ration can be reduced upto 20% of the Morrison standards if situation demands, without effect on growth rate. But decrease in energy intake has quite adverse effect on growth.

Growth in body measurements:

Body measurements in the form of length, heart-girth and height at withers of all calves were recorded before the start of the experiment and after its completion, and the data are presented in table 4.17.

The average growth in length, heart-girth and height for the group A is 11.1, 13.8, 11.2 cm. respectively; for group B,11.2, 13.2, 10.8 cm. and for group C, 11.0, 10.0,9.8 cm., respectively for the entire period. Growth in length is almost similar in all the groups. There is marked decrease in growth of girth and to lesser degree in height in group C due to the lower level of energy intake affecting growth in body weight. The effects is more marked on heart girth and to a lesser extent on height.

Our observation is in general agreement with Clanton et al. (1964). They recorded that for approximately 40% decrease in growth in weight due to energy restriction,there was simultaneous decrease of about 39% in the growth of heart-girth and 10.5% decrease in growth of height.Our values are about 22% decrease in growth of weight,resulting in about 28% decrease in growth of heart-girth and about 3.6% decrease in growth in height. No published data is available for comparing the adverse effects of growth in length of the body.

TABLE 4.17

Body measurements of calves before and after the experiment.

Group	Animal No.	Length (cm.)			Heart-girth (cm.)			Height (cm.)		
		Initial	Final	Difference.	Initial	Final	Difference.	Initial	Final	Difference.
A	156	80	91	11	118	131	13	104	116	12
	161	85	95	10	130	145	15	105	117	12
	19	83	96	13	123	135	12	105	115	10
	72	79	90	11	116	131	15	98	109	11
Average		81.7	93.0	11.1	121.7	135.5	13.8	103.0	114.2	11.2
B	155	82	92	10	121	135	14	93	106	13
	159	80	92	12	118	130	12	99	110	11
	39	85	94	9	125	141	16	107	116	9
	46	84	98	14	116	127	11	104	114	10
Average		82.7	94.0	11.2	120.0	133.2	13.2	100.7	111.5	10.8
C	162	77	90	13	114	124	10	97	108	11
	8	81	91	10	120	132	12	102	111	9
	11	83	92	9	120	129	9	101	112	11
	74	79	91	12	123	132	9	103	111	8
Average		80.0	91.0	11.0	119.2	129.2	10.0	100.7	110.5	9.8

V. Efficiency of feed coversion

Dry matter and various amounts of nutrients consumed by calves in three groups are already presented in tables 4.13A, B and C.

TABLE 4.18

Efficiency of feed and nutrient utilisation for growth (Pooled performance of calves in group).

Sl. No.	Particulars	Group A	Group B	Group C
1	Total increase in weight (kg.)	197	191	143
2	Dry matter intake (kg.)	1273.64	1272.47	1054.13
3	Crude protein intake (kg.)	217.02	181.48	220.12
4	Digestible crude protein (kg.)	173.82	141.55	189.30
5	Total digestible nutrient -s (kg.)	768.08	792.32	729.42
6	Estimated net energy (Therm.)	1483.64	1548.22	1383.08
	For each kg. in growth, the requirement of ..			
7	Dry matter (kg.)	6.468	6.661	7.372
8.	Crude protein (kg.)	1.099	0.950	1.539
9	Digestible crude protein (kg.)	0.881	0.739	1.323
10	Total digestible nutrients (kg.)	3.899	4.149	5.100
11	Estimated net energy (Therm.)	7.534	8.114	9.674

Dry matter consumption per each kg. of growth is least in group A, 6.468 kg. followed by 6.661 kg. for group B and 7.372 kg. for group C (Table 4.18). This means that the efficiency of dry matter utilisation for growth is maximum in group A.

Regarding efficiency of utilisation of crude protein, it is maximum in group B and minimum in group C.

TDN consumption for each kg. of gain is 3.899, 4.149 and 5.100 kg. for groups A,B and C respectively. Sharma (1962) worked on Tharparkar calves of about 5 months old and found that 1 kg. growth required 3.44 kg. TDN. Verma (1963) with one year old calves of same breed, got the figure of 3.411 kg. and Dalai (1966) obtained the figure of 4.600 kg. for calves aged about 1 year 2 months.

Results of group A and B of the present study are comparable to their findings. TDN requirement for group C of 5.100 kg. appear to be very high compared to 3.805 for group A. While discussing the digestion trial data, it was pointed out that group C almost equalled group A, in TDN, due to higher degree of digestion of all nutrients except NFE.

Inspite of nearly equal TDN intake, group C calves could not gain to the same extent as group A, which reveals that considerable amount of energy was lost from the digested nutrients in this group.

Group C had digested on an average about 123 g. of crude fibre, 40 g. of crude protein and 25 g. of ether extract more per day more than group A. It is well known that the net energy from digested crude fibre is comparatively less, as products of digestion of fibre has high proportion of acetic acid, which loses about 45-50% of caloric value in metabolism (Armstrong and Blaxter,1956). Acetic acid further increases urinary nitrogen excretion (Armstrong et al.,1957).

Thus the non-nitrogenous net energy intake of group C might be below the maintenance requirement and protein would have been used inefficiently as source of energy resulting in observed increase of urinary nitrogen excretion. This view is supported by Lofgreen et al.(1951), Rosenthal and Allison(1956) and Iwao Tabaki and Junichi Okumara (1964).

Gahn and Hougat (1960) and Bogomolov (1960) had reported that protein had greater specific dyanamic effect and part of combustible energy of the aminoacids would have been excreted as urea along with other metabolites, and is estimated by Blaxter (1956) to be about 16% of the combustion of protein dissimilation.

Popehima (1956) and Vortilov (1957)reported lower growth rates in pigs fed on rations with high DCP. Cunningham(1960) reported that pigs reared at uniform energy supply of 33 Kcal/kg. body weight gained on average 1 kg.per day on rations containing 16% protein, while pigs on rations containing 26% protein lost 29 g. per day.

Though group C has apparently digested 25 g. more of ether extract than that of group A, its ultimate energy value

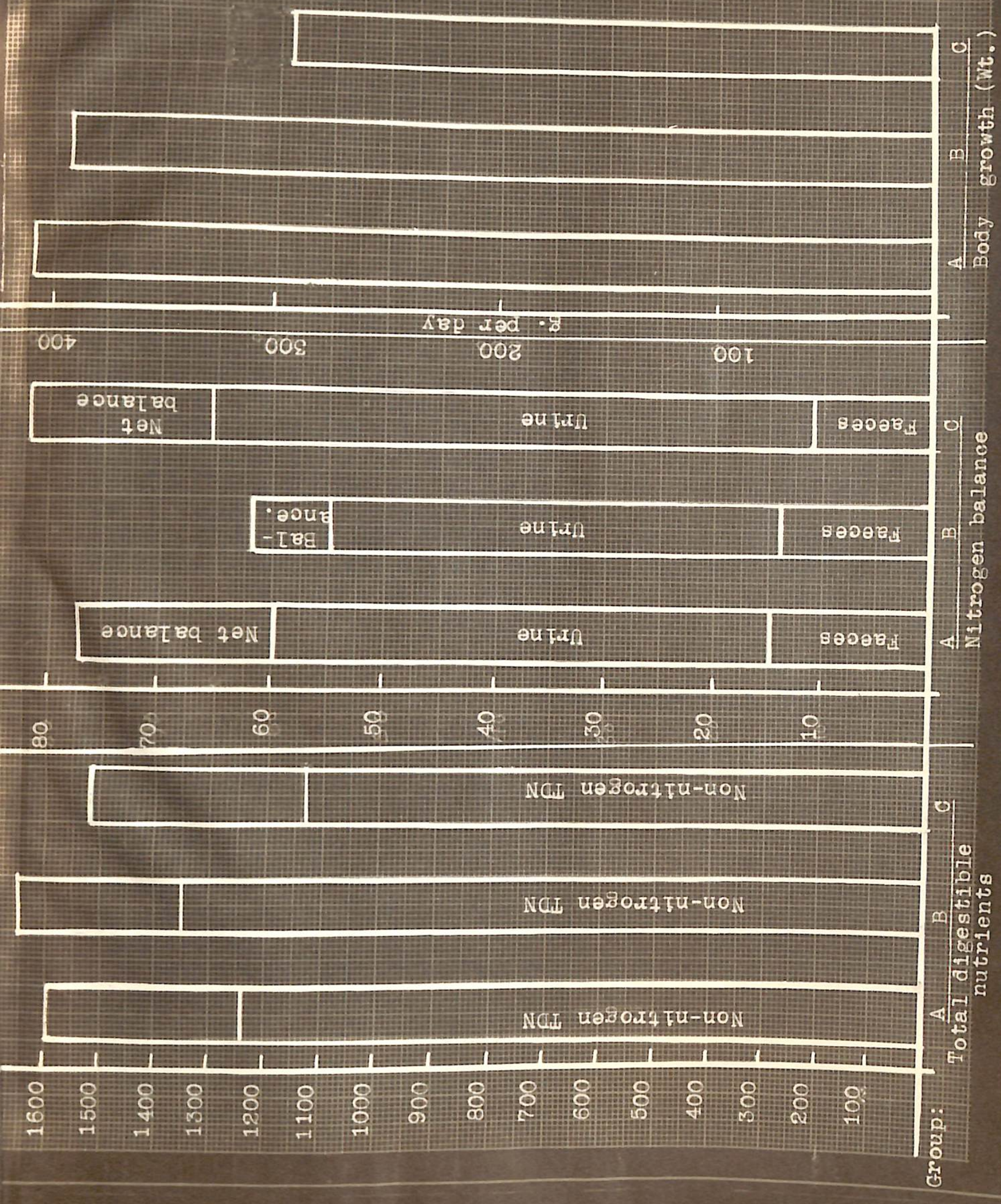


Fig.3: Comparison of the TDN and non-nitrogen TDN intakes, nitrogen balance and growth in weight in the three groups.

is in doubt. As pointed out earlier while discussing the significance of digestion coefficient for ether extract, this increased ether extract digestion might be due to improved reabsorption of bile constituents which otherwise under liberal feeding condition, would have been partially excreted. These constituents may not be having the same energy value as lipids in the body.

These increased losses in energy due to specific dynamic action, urea nitrogen excretion, and non-availability of the expected energy from the ether extract component, might have lowered the net energy available for this group, so that it was not sufficient for comparable performance in growth with that of group A.

VI. Total digestible nutrient intake by experimental calves, using Morrison's digestible coefficients for the feeding stuffs:

The digestion trial conducted at the end of this experiment gave varying digestion coefficients for the various nutrients, in the different groups. Though probable causes for the differences were discussed, no clear experimental evidence could be cited in support of some of these deductions. As the digestion coefficients were estimated with two animals only, a high degree confidence is not possible in the results.

Hence the average TDN consumption of experimental animals is now calculated, using Morrison's digestion coefficients. The total ration intake is subdivided into intakes of Paragrass, ground nut cake and wheat bran. Taking into consideration the digestible coefficients forthe above feeding stuffs as given in table I in the appendix of "Feeds and Feeding" by Morrison(1959), the TDN intake by each group is calculated and presented in table 4.19.

Average TDN consumption per calf per day is worked out to be 1.952, 1.946 and 1.524 kg. for groups A, B and C respectively. From the results, animals of groups A and B appear to have consumed more TDN per day compared to the value calculated on our digestion trial data. TDN consumption in group C is almost the same in both the cases. There is considerable difference in TDN consumption between groups A and C and B and C, and the TDN consumption in groups A and B is almost equal , as anticipated. TDN intake of group C is about 22% less than group A. DCP consumption in groups A and C is almost similar but consumption in group B is 22% less than group A.

The efficiency of nutrient conversion calculated as per the Morrison's digestion coefficients are presented in table 4.20.

Efficiency of utilisation of digestible crude protein is maximum in group B and minimum in group C. T.D.N. consumption for each kg. of gain is 4.760, 4.889 and 5.113 kg. for groups A, B and C respectively, indicating that low energy group (C) had least efficiency in utilisation of both protein and energy.

TABLE 4.19

Nutrients and TDN intake by calves using Morrison's digestibility coefficients.

Particulars	C.P.	C.F.	N.F.E.	E.E.	TDN
Group A					
Green Paragrass (kg.)	39.22	138.61	212.13	8.75	-
Dig.coefficient(%)	56	56	61	62	-
Dig. nutrients (kg.)	21.97	77.62	129.40	5.42	241.19
Ground nut cake (kg.)	77.20	19.10	39.39	15.11	-
Dig. coefficient(%)	91	51	87	92	-
Dig. nutrients(kg.)	70.25	9.74	34.26	13.90	145.53
Wheat bran .... (kg.)	97.21	70.26	402.00	29.48	-
Dig. coefficient(%)	84	70	91	81	-
Dig. nutrients(kg.)	81.47	49.19	365.80	23.89	550.21
Total for 4 calves;120 days(kg.):	-	-	-		936.93
Group B					
Green Paragrass (kg.)	39.08	138.47	212.79	8.75	-
Dig. coefficient(%)	56	56	61	62	-
Dig. nutrients(kg.)	21.89	77.57	129.80	5.42	241.46
Ground nut cake (kg.)	15.49	3.83	7.90	3.03	-
Dig. coefficient(%)	91	51	87	92	-
Dig. nutrients(kg.)	14.09	1.95	6.88	2.79	29.20
Wheat bran .... (kg.)	117.00	84.59	484.00	35.50	-
Dig. coefficient(%)	84	70	91	81	-
Dig. nutrients(kg.)	99.31	59.21	440.30	28.76	663.53
Total for 4 calves;120 days(kg.)	-	-	-		934.19

TABLE 4.19(contd.)

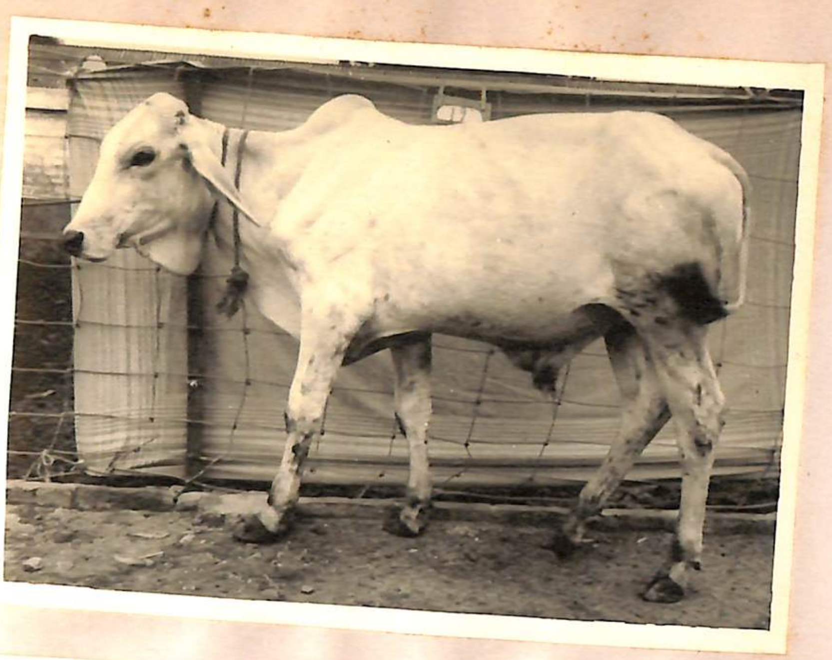
Particulars	C.P.	C.F.	N.F.E.	E.E.	TDN
Group C					
Green Paragrass (kg.)	49.12	173.93	264.28	10.97	-
Dig. coefficient(%)	56	56	61	62	-
Dig. nutrients(kg.)	27.51	92.29	161.20	6.80	296.31
Ground nut cake (kg.)	141.60	35.03	72.24	27.71	-
Dig. coefficient(%)	91	51	87	92	-
Dig. nutrients(kg.)	128.80	17.86	62.85	25.50	266.88
Wheat bran .... (kg.)	29.74	21.40	122.90	9.02	-
Dig. coefficient(%)	84	70	91	81	-
Dig. nutrients(kg.)	24.98	15.04	111.90	7.31	168.36
Total for 4 calves;120 days (kg.)		-	-	-	731.55

TABLE 4.20

Average DCP and TDN intake and efficiency of nutrient conversion in different groups, calculated as per Morrison's digestion coefficients.

Particulars	Groups A	Groups B	Groups C
Average daily gain (g.)	411	398	298
DCP intake (g.)/day	362	282	374
TDN intake (kg.)/day	1.952	1.946	1.524
Nutrient requirement for each kg. growth in body wt:			
DCP ... (kg.)	0.883	0.725	1.255
TDN ... (kg.)	4.760	4.889	5.113

.....



GROUP - A

Calf No. 19/66.

Age†: 1 yr. 3 months.

49 kg. growth in 120 days.

GROUP - B

Calf No. 39/66.

Age†: 1 yr. 2 months.

46 kg. growth in 120 days.

GROUP - C

Calf no. 11/66.

Age†:1 yr. 4 months.

34 kg. growth in 120 days.

(† at the beginning of the experiment)

Fig.4: Photographs of representative calf of each group at the end of the experiment.

CHAPTER - V

S U M M A R Y

S U M M A R Y

The object of the experiment was to study the effects of reduced protein and energy levels on growth rate of calves.

Twelve Tharparkar male calves of age ranging from 11 to 16 months were selected for conducting the experiment at the Government Cattle Farm, Patna. The calves were distributed into three similar groups (A, B and C), according their body weight and age. Group A (control) was fed on Morrison feeding standard, group B on 20% less DCP but equal TDN to group A and group C on equal DCP but 20% less of TDN, compared to group A.

Three different concentrate mixtures were prepared, one for each group, consisting of ground nut cake and wheat bran in different proportions, to give the desired level of crude protein. The crude protein content of the concentrate mixtures was 21.4, 17.0 and 33.9% (on dry matter basis) for groups A, B and C respectively. Green Paragrass was used as sole roughage throughout the experimental period.

At the beginning of the experiment, the calves in groups A and B received 1.8 kg. of concentrate mixture and 4 kg. of green Paragrass/calf/day whereas, calves of group C received 1.1 kg. of concentrate mixture and 5 kg. of green

Paragrass, which was estimated to supply the desired level of nutrients to each group. The concentrate ration was increased by 100 g. every month to meet increased maintenance requirement.

All the calves were weighed once every fortnight. Body measurements in the form of length, heart-girth and height were also recorded before and after the experiment.

The feeding trial lasted for a period of 120 days, at the end of which, simultaneous digestion and nitrogen balance trials were conducted with two animals from each group for a 8 days' period. An attempt was made to estimate the fecal output by 'Chromic oxide indicator technique', using grab-samples of faeces collected at 6 a.m. and 4 p.m.

Digestible nutrient intake and efficiency of feed and nutrient conversion for growth were calculated using the digestion coefficient data obtained from our digestion trial, as also with Morrison's digestion coefficients.

The average growth rate in calves during the period of experiment was 411, 398 and 298 g./day for groups A,B and C respectively. The growth rate of calves in group C was found to be significantly lower (P∠01) than that of groups A and B. The average increases in length, heart-girth and height for group A were 11.1, 13.8 and 11.2 cm. respectively. The values for group B and C in order, were 11.2, 13.2 and 10.8 cm.; and 11.0, 10.0 and 9.8 cm. for the entire period. There was marked decrease in growth of heart-girth in group C.

Calves of group C gave higher digestibility coefficients for all nutrients except NFE than the other groups. Probable reasons for the increased digestibility coefficients were discussed basing on dry matter intake, nutritive ratio and ether extract content of the rations. Due to higher digestibility coefficients obtained by us, the TDN intake of group C worked out to be almost equal to groups A and B. Chromic oxide indicator technique, using grab-samples, gave considerably high estimates of dry matter output, due to low recovery of chromic oxide in the grab-samples.

All the calves were having positive nitrogen balance, average being 17.2 g./day for group A, 8.9 g/day for group B and 16.3 g./day for group C. Efficiency of retained-N for growth was maximum for group B (22.4g of N/kg.growth) and minimum for group C (54.80 g.of N/kg.growth).

Average consumption of digestible nutrients by the calves worked out to be DCP 361, 295 and 394 g./day and TDN 1.60, 1.65 and 1.52 kg./day for groups A,B and C respectively. Efficiency of TDN conversion was maximum in group A (3.90 kg. of TDN/kg.growth) and minimum in group C (5.10 kg.of TDN/kg. growth).

Average TDN consumption by calves was also calculated using the digestion coefficient values, given by Morrison

(1959). Average TDN consumption on these values worked out to be, 1.95, 1.95 and 1.52 kg./day for groups A,B and C respectively. The groups A and B appear to have consumed more TDN per day, compared to the values calculated as per our digestion trial data. TDN consumption in group C was almost the same in both cases.

These findings indicate that reduction of about 20% protein in the standard ration did not affect the growth rate, but reduction of 20% energy had considerable adverse effect on the growth of calves in the age group of 11 to 16 months.

.....

B I B L I O G R A P H Y

BIBLIOGRAPHY

Agarwala, O.P. and Sundaresan, D.(1956). Cheaper high protein versus expensive low protein rations for growth and fattening pigs in India, Indian J.Vet.Sci., 26:185.

Armsby, H.P.(1930). Nutrition of farm animals, (The Macmillan Company, New York).

Armstrong, D.G.and Blaxter, K.L.(1956). Heat increments of feeding in ruminants, Nature, 177:1183.

Idem (1957). The heat increment of steam-volatile fatty acids in fasting sheep, Brit.J.Nutrition, 11:247.

Armstrong, D.G., Blaxter, K.L. and Graham, N.M.,(1957). The heat increments of mixtures of steam-V.F.A. in fasting sheep, Ibid, 11:392.

Armstrong, D.G. and Blaxter, K.L.(1957). The utilisation of acetic, propionic and butyric acids by fattening sheep, Ibid, 11:413.

Association of Official Agricultural Chemists (1940). Official and tentative methods of Analysis (A.O.A.C.Washington).

Balch, C.C., Reid, J.T. and Strond, J.W.(1957). Factors influencing the rate of excretion of administered chromium sesquioxide by steers, Brit. J.Nutrition, 11:184.

Bhattacharya, N.K. and Soni, B.K.(1966-67). Some mechanical factors in ruminent digestion(Animal Nutrition Research Workers Conference, Trichur).

Blaxter, K.L. (1951). The nutrition of young Ayrshire calf-I, Brit.J.Nutrition, 5:25.

Idem (1956).The nutritive value of feeds as sources of energy, J.Dairy Sci., 39:1396.

Blaxter, K.L. and Graham, N.M. (1955). Plane of nutrition and starch equivalents, J.Agric.Sci., 46:292 (N.A.& R., 26:Abst. 2444).

Blaxter, K.L. and Martin, A.K. (1962). The utilisation of protein as a source of energy in fattening sheep, Brit. J.Nutrition, 16:397.

Bloom, S., Jacobson, N.L., Allen, R.S., Mc.Gillard, L.D. and Homeyer, P.G.(1957). Effects of various hay:concentrate ratios on nutrient utilisation and production responses of dairy cows.2) Observations on ration digestibility and on the excretion pattern of chromic oxide, J.Dairy Sci.,40: 240.

Bogomolov, N.A.(1960). Specific dynamic action of protein feeds in cattle, Fiziol Z.SSSR Secenova,46:992. (N.A.& R., 31:Abst. 2438).

Bolin, D.W., King, R.P. and Klosterman, E.W. (1952). A simplified method for the determination of chromic oxide (Cr_2O_3) when used as an index substance, Science, 116:634.

Brisson, G.J., Cunningham, H.M. and Haskell, S.R.(1957). The protein and energy requirement of young dairy calves, Canad.J.Animal Sci., 37:157, (N.A.& R., 28: Abst.4379).

Brisson, G.J., Pigden, W.J. and Sylvestre, P.E.(1957). Effect of frequency of administration of Cr_2O_3on its fecal excretion pattern by grazing cattle. Canad.J.Animal Sci.,37:90(N.A.& R.,28:Abst. 1351)

Brown, L.D. and Lassister, C.A.(1961). Protein-Energy ratio studies in dairy calves, J.Dairy Sci., 44: 1185.

Cahn, T. and Houget, J. (1960). Specific dynamic action, C.R.Acad.Sci.,251:452 (N.A.& R.,31:Abst.642).

Chaudhary, H.P.S. and Majumdar, B.N.(1962). Comparative usefulness of the indicator technique in digestibility determinations in different species of animals, Ann.Biochem.Exp.Med.,22:297, (N.A. & R. 33:5098).

Clanton, D.C. (1961). Comparison of 7- and 10- day collection periods in digestion and metabolism trials with beef heifers, J.Animal Sci., 20:640.

Idem (1962). Variations in chromic oxide methods of determining digestibility of Hand-fed Beef cattle rations, Ibid, 21:214.

Clanton, D.C., Zimmerman, D.R. and Albin, R.C. (1964). Effect of protein and energy levels on growth and pubertal age in beef heifers, Ibid, 23:870.

Clawson, A.J., Reid, J.T., Sheffy, B.E. and Willman, J.P. (1955). Use of chromic oxide in digestion studies with swine, Ibid, 14:700.

Corbett, J.L., Greenhalgh, J.F.D., Mc.Donald, I. and Florence, E. (1960). Excretion of chromium sesquioxide administered as a component of paper to sheep, Brit. J. Nutrition, 14:289.

Corroll, F.D., Nelson, D.D., Wold, H. and Plang, G. (1964). Energy utilisation in heifers as affected by a low-protein iso caloric diet, J.Animal Sci., 23:758.

Crampton, E.W. and Lloyd, L.E. (1951). Studies with sheep on the use of chromic oxide as an index of digestibility of Ruminent rations, J.Nutrition, 45:319.

Crampton, E.W., Lloyd, L.E. and MacKay, V.G. (1957). The caloric value of TDN., J.Animal Sci., 16:541.

Crichton, T.A., Aitken, J.N. and Boyne, A.W. (1959). The effect of plane of nutrition during rearing on growth, production, reproduction and health of dairy cattle, Animal Production, 1:145 (N.A.& R.30: Abst.2986).

Cunningham, H.M. (1960). Protein storage of pigs in the absence of body weight gain. Canad J.Animal Sci., 40:1 (N.A.& R.31: Abst.692).

Cunningham, H.M., Haskell, S.R., Miles, V.J., Logan, V.S. and Brisson, G.J. (1958). Further studies on the protein and energy requirements of young dairy calves, Canad J. Animal Sci., 38:37 (N.A.& R., 29: Abst.1515).

Dalai, R.K. (1966). Growth studies of Tharparkar calves on three levels of Nutrition, M.Sc. (A.H.) Thesis, submitted to Magadh University.

Dansky, L.M. and Hill, F.W. (1952). Application of the chromic oxide indicator method to balance studies with growing chicken, J.Nutrition, 47:449.

Idem (1962). Variations in chromic oxide methods of determining digestibility of Hand-fed Beef cattle rations, Ibid, 21:214.

Clanton, D.C., Zimmerman, D.R. and Albin, R.C. (1964). Effect of protein and energy levels on growth and pubertal age in beef heifers, Ibid, 23:870.

Clawson, A.J., Reid, J.T., Sheffy, B.E. and Willman, J.P. (1955). Use of chromic oxide in digestion studies with swine, Ibid, 14:700.

Corbett, J.L., Greenhalgh, J.F.D., Mc.Donald, I. and Florence, E. (1960). Excretion of chromium sesquioxide administered as a component of paper to sheep, Brit. J. Nutrition, 14:289.

Corroll, F.D., Nelson, D.D., Wold, H. and Plang, G. (1964). Energy utilisation in heifers as affected by a low-protein iso caloric diet, J.Animal Sci., 23:758.

Crampton, E.W. and Lloyd, L.E. (1951). Studies with sheep on the use of chromic oxide as an index of digestibility of Ruminent rations, J.Nutrition, 45:319.

Crampton, E.W., Lloyd, L.E. and MacKay, V.G. (1957). The caloric value of TDN., J.Animal Sci., 16:541.

Crichton, T.A., Aitken, J.N. and Boyne, A.W. (1959). The effect of plane of nutrition during rearing on growth, production, reproduction and health of dairy cattle, Animal Production, 1:145 (N.A.& R.30: Abst.2986).

Cunningham, H.M. (1960). Protein storage of pigs in the absence of body weight gain. Canad J.Animal Sci., 40:1 (N.A.& R.31: Abst.682).

Cunningham, H.M., Haskell, S.R., Miles, V.J., Logan, V.S. and Brisson, G.J. (1958). Further studies on the protein and energy requirements of young dairy calves, Canad J. Animal Sci., 38:37 (N.A.& R., 29: Abst.1515).

Dalai, R.K. (1966). Growth studies of Tharparkar calves on three levels of Nutrition; M.Sc. (A.H.) Thesis, submitted to Magadh University.

Dansky, L.M. and Hill, F.W. (1952). Application of the chromic oxide indicator method to balance studies with growing chicken, J.Nutrition, 47:449.

Idem (1962). Variations in chromic oxide methods of determining digestibility of Hand-fed Beef cattle rations, Ibid, 21:214.

Clanton, D.C., Zimmerman, D.R. and Albin, R.C.(1964). Effect of protein and energy levels on growth and pubertal age in beef heifers, Ibid, 23:870.

Clawson, A.J., Reid, J.T., Sheffy, B.E. and Willman, J.P.(1955). Use of chromic oxide in digestion studies with swine, Ibid, 14:700.

Corbett, J.L., Greenhalgh, J.F.D., Mc.Donald, I. and Florence, E. (1960). Excretion of chromium sesquioxide administered as a component of paper to sheep, Brit. J. Nutrition, 14:289.

Corroll, F.D., Nelson, D.D., Wold, H. and Plang, G.(1964). Energy utilisation in heifers as affected by a low-protein iso caloric diet, J.Animal Sci., 23:758.

Crampton, E.W. and Lloyd, L.E. (1951). Studies with sheep on the use of chromic oxide as an index of digestibility of Ruminent rations, J.Nutrition, 45:319.

Crampton, E.W., Lloyd, L.E. and MacKay, V.G.(1957). The caloric value of TDN., J.Animal Sci., 16:541.

Crichton, T.A., Aitken, J.N. and Boyne, A.W.(1959). The effect of plane of nutrition during rearing on growth, production, reproduction and health of dairy cattle, Animal Production, 1:145(N.A.& R.30: Abst.2986).

Cunningham, H.M.(1960). Protein storage of pigs in the absence of body weight gain. Canad J.Animal Sci., 40:1 (N.A.& R.31: Abst.682).

Cunningham, H.M., Haskell, S.R., Miles, V.J., Logan, V.S. and Brisson, G.J. (1958). Further studies on the protein and energy requirements of young dairy calves, Canad J. Animal Sci., 38:37(N.A.& R., 29:Abst.1515).

Dalai, R.K.(1966). Growth studies of Tharparkar calves on three levels of Nutrition; M.Sc.(A.H.)Thesis, submitted to Magadh University.

Dansky, L.M. and Hill, F.W.(1952). Application of the chromic oxide indicator method to balance studies with growing chicken, J.Nutrition, 47:449.

Dasgupta, N.C. (1943). Green Berseem as a substitute for concentrates for economic feeding of dairy cattle, Indian J.Vet.Sci., 13:196.

Davis, C.L., Byers, J.H. and Luber, L.E.(1958). An evaluation of chromic oxide method for determining digestibility, J.Dairy Sci., 41:152.

Deinum, B., Immink, H.J. and Deijs, W.B. (1962). The excretion of chromium sesquioxide in faeces by cows after administration of Cr_2O_3- containing paper, Jaarb.Inst.Biol.Scheik.Meded No 188:123. (N.A.& R.,33:Abst.5097).

Erwin, E.S., Algeo, J. and Gordon, R.S.(1961). Effect of protein-energy on steer performance and rumen V.F.A., J. Animal Sci., 20:931.

Faltova, E. and Poupa, O.(1956). The effect of a diet with high protein content on growth, Csl.gastroenterol.a vyz., 10:229 (N.A.& R.,27:Abst.612).

Fontenot, J.P., Gallup, W.D. and Nelson, A.B.(1955). Effect of added carbohydrate on the utilisation by steers of nitrogen in wintering rations, J.Animal Sci., 14:807.

French, M.H.(1956). The effects of restricted intakes on the digestibility of hays by East African hair-sheep and Zebu oxen, Empire.J.Exp.Agric., 24:235 (N.A.& R.,27:Abst.2606).

Gehrke, C.W.(1960). The quantitative determination of Chromic oxide in feeds and faeces (personal communication).

Gopalan, C. and Narasingarao, B.S.(1966). Effect of protein depletion on urinary nitrogen excretion in under nourished subjects, J.Nutrition, 90:213.

Hammond, J. (1955). Progress in the Physiology of Farm animals, vol.2 (Butter worths Scientific Publications, London).

Hardison, W.A., Garf, G.C. and Engel, R.W.(1954). Fecal chromic oxide concentration in 12 Dairy cows as related to time and frequency of administration and to feeding schedule, J.Animal Sci., 13:1009.

Hardison, W.A., Linkons, W.N., Engel, R.W. and Garf, G.C.(1959). Observations on the use of chromic oxide for estimating fecal output of Dairy animals, J.Dairy Sci., 42:346.

Hardison, W.A., and Reid J.T. (1953). Use of indicator in the measurement of the dry matter intake of grazing animals, J. Nutrition, 51:35.

Hartfiel, W. (1960). Metabolism trials with calves and problems of estimating fat in the faeces, Arch. Tierenahrung 10:264 (N.A.& R., 31:Abst., 3070).

Hartsook, E.W. and Hershberger, T.V. (1963). Influence of low, intermediate and High levels of Dietary protein on Heat production of rats, J. Nutrition, 81:209.

Hawking, W.W. (1952). The teaching of specific dynamic action, Science, 116:19.

Hendrickson, R.F., Pope, L.S., Hendrickson, R.L. and George Waller (1961). Effect of High Vs. Moderate planes of Nutrition on feed lot performance and carcass characteristics, J. Animal Sci., 20:1961.

Holmes, W., Waite, R., Maclusky, D.S. and Watson, J.N. (1956). Winter feeding of Dairy cows. I. The influence of level and source of protein and of the level of energy in the feed on milk yield and composition, J. Dairy Res., 23:1 (N.A.& R., 26:Abst. 3849).

Irwin, H.M., Shaw, J.C., Saarinen, P. and Moore, L.A. (1951). Net energy Vs. T.D.N. in evaluating the efficiency of an all-alfalfa hay ration for milk production, J. Animal Sci., 10:947.

Irwin, M.I. and Crompton, E.W. (1951). The use of Chromic oxide as an index material in digestion trials with human subjects, J. Nutrition, 43:77.

Indian Standards Institution, (1960). Specification for mineral mixture for supplementing cattle feeds IS:1664-1960 (I.S.I. New Delhi).

Iwao Tabaki and Junichi Okumara (1964). Effect of protein level of Diet on nitrogen excretion in fowls, J. Nutrition, 83:24.

Jacobus, P.H., Wessels and Fisher, H. (1965). Estimation of protein reserves and the N-content of organs in protein - depleted and repleted cocks, Brit. J. Nutrition, 19:57.

Kameoka, K., Takahashi, S. and MoriMoto, H. (1956). Variation in the excretion of chromic oxide by ruminents, J. Dairy Sci., 39:462.

Kane, E.A., Jacobson, W.C. and Damewood, P.M.(1957). The measurement of digestibility by means of a radio active isotope, Ibid, 40:612.

Idem (1959). Use of Radio active chromium oxide in digestibility determinations, Ibid, 42:1359.

Kane, E.A., Ely, R.E., Jacobson, W.C. and Moore, L.A.(1953). A comparison of various digestion trial techniques with dairy cattle, Ibid, 36:325.

King, W.A., Lee, J.(III)., Webb, H.J. and Roderick, D.B.(1960). Comparison of 6- and 10- day collection periods for digestion trials with dairy heifers, Ibid, 43:388 (N.A.& R.,31:Abst.1361).

Koch, R.M., Schleicher, E.W. and Arthaud, V.H.(1958). The accuracy of weights and gains of beef cattle, J.Animal Sci., 17:604.

La Grutta, G. and Cilento, A. (1954). Nitrogenous substances and water content of growing rats during under feeding and subsequent re-feeding, Arch.Sci. biol., Bologna,38:366 (N.A.& R.,25:760).

Lander, P.E.(1949). Feeding of Farm animal (Macmillan & Co., Bombay).

Lassister, C.A., Huffman, C.F.and Duncan, C.W.(1957). The effect of varying hay-grain ratios and levels of feed intake on feed utilisation of Dairy cows, J.Dairy Sci.,40:611.

Lery, C.G.(1960).Influence of nutritional state of the pig on basal metabolism, C.R.Acad.Sci.,251:455. (N.A.& R.,31:Abst.640).

Linnerud, A.C. and Donker, J.D.(1961). Factors affecting the excretion pattern of chromic oxide in faeces of Dairy cows on pasture, J. Dairy Sci.,44:1176.

Lloyd, L.E., Rutherford, B.E. and Crampton,E.W.(1955). A comparison of titanic oxide and chromic oxide as index materials for determining apparent digestibility, J.Nutrition, 56:265.

Lofgreen, G.P.,Loosli, J.K. and Maynord, L.A.(1951a). The influence of Energy intake on the nitrogen retention of growing calves, J.Dairy Sci., 34:911.

Idem (1951b). Comparative study of conventional protein allowances and theoretical requirements of growing Holstein heifers,J.Animal Sci.,10:171.

Lofgreen, G.P. and Max Kleiber (1953). The metabolic fecal nitrogen excretion of the young calf and the true digestibility of casein, J.Nutrition, 49:183.

Mac Donald, M.A.(1957). Effect of plane of intake of TDN on rate and efficiency of gain in identical twin steers, N.Z.J.Sci.Technol (A), 38:987 (N.A.& R.,28:Abst.4395).

Majumdar,B.N., Gupta, B.N. and Kehar, N.D.(1962). I.studies on indirect methods of determining feed digestibilities and herbage intakes of grazing animals Ann.Biochem. Exp.Med.,22:13(N.A.& R.,33:1374).

Majumdar,B.N. and Gupta, B.N.(1962).II.Pattern of excretion of Cr_2O_3in the faeces of grazing animals vis-a-vas stall fed animals, Ibid,22:91 (N.A.& R.,33:1374).

Makela, A. (1956). Studies on the question of bulk in the nutrition of Farm animals with special reference to cattle, Acta agrl.fenn.,1956 pp.139 (N.A.& R.,26:Abst.5123).

Mathur, M.L. and Ghosh, S.N. and Sampath, S.R.(1963). Studies on Paragrass:Effect of replacing 25% production ration with Paragrass on the milk and fat production in milk cows, Indian J.Dairy Sci., 16:9.

Mathur, M.L., Pherwani, M.S., Rangaswamy, M.C. and Sen, K.C. (1957). Studies on Paragrass, Ibid, 10:85. (N.A.& R.,28:2975).

Maynard, L.A.(1956).Animal Nutrition,Asian Students Ed. (KOGAKUSHA CO.Ltd.,Tokyo).

McCullough, M.E.(1953). The use of indicator methods in measuring the contribution of the two forages to the total ration of the dairy cow, J.Dairy Sci., 36:445.

Morrison, F.B.(1959). Feeds and Feeding 22nd Ed.(The Morrison, Publishing Co.,Clinton,Iowa).

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

Idem (1965b). Effect of feeding different levels of protein on the growth of Sahiwal calves, Ibid, 18:21.

Idem (1965c). Growth studies on Indian Breeds of cattle.II. Studies on the growth of Sahiwal cattle, Ibid, 18:65.

Idem (1965d). Studies on the nutrients required for growth. Nitrogen metabolism in growing cattle when fed with three levels of protein, Ibid, 18:119.

Mudgal, V.D. (1966-67). Nutritive requirements of growing Indian cattle. (Animal Nutrition Research Workers Conference, Trichur).

Paloheimo, L. and Makela, A. (with Sevanto A)(1959). Further studies on the retention time of food in the digestive tract of cows, Acta.Agral.fenn., 94:15 (N.A.& R., 30:Abst.4938).

Pfander, W.H., Roberts, D., Comfort, J.E. and Jones, J.G.W. (1957). Digestibility of wheat, sudan grass and drouth corn silages by wethers and steers, Missouri Agric.Exp.Stat.Res.Bull.No.628:8.

Piatkouski, B., Steger, H. and Puschel (1962). Estimation of chromic oxide and its excretion by Dairy cows in stalls and on pasture, Arch.Tierernahrung 12:137 (N.A.& R., 33:Abst.3498).

Pigden, W.J. and Brisson, G.J. (1956). Effect of frequency of administration of chromic oxide on its fecal excretion pattern by growing wethers, Canad. J.Agric.Sci., 36:146 (N.A.& R., 26:Abst.5127).

Popehina, P.S. (1956). Protein level in rations for pork pigs, Svinovodstvo, No.2:44 (N.A.&.R., 27:Abst.2734).

Preston, R.L. (1966). Protein requirements of growing -finishing cattle and lambs, J.Nutrition, 90:157.

Putnam, P.A. (1962). Survey on the use of chromic oxide in ruminent research, J.Animal Sci., 21:139.

Putnam, P.A. and Loosli, J.K. (1959). The effect of feeding different ratios of roughage to concentrate upon milk production and digestibility of the ration, J.Dairy Sci., 42:1070.

Putnam, P.A., Loosli, J.K. and Warner, R.G. (1958). Excretion of chromic oxide by dairy cows, Ibid, 41:1723.

Ranjhan, S.K. and Talapatra, S.K. (1963). Growth response in Hariana calves. I. Berseem as a growth production ration, Indian J. Dairy Sci., 16:166.

Riba, E. (1961). Effect of level of protein in fattening pigs for bacon, Teaduslike Toode Kogumik, 5:191. (N.A.& R., 33:Abst.5318).

Richardson, D., Smith, E.F., Baker, F.B. and Cox, R.F. (1961). Effects of roughage-concentrate ratio in cattle fattening rations on gains, feed efficiency digestion and carcass quality, J. Animal Sci., 20:316.

Rokushima, H. (1961). Amount of protein intake and specific dynamic action of amino acid., J.Jap.Soc. Food nutrition 13:426 (N.A.& R., 32:Abst.628).

Rosenthal, H.L. and Allison, J.B. (1956). Effect of caloric intake on nitrogen balance and organ composition of adult rats, J.Agric.Food.Chem., 4:792 (N.A.& R., 27:Abst., 564).

Schurch, A.F., Crampton, E.W., Haskell, S.R. and Lloyd, L.E. (1952). The use of chromic oxide in digestibility studies with pigs fed ad libitum in the barn, J, Animal Sci., 11:261.

Schurch, A.F., Lloyd, L.E. and Crampton, E.W. (1950). The use of chromic oxide as an index for determining the digestibility of a diet, J.Nutrition, 41:629.

Sen, K.C. (1953). Animal Nutrition Research in India (Macmillan and Co. Ltd. Calcutta, Bombay, Madras and London).

Sen, K.C. and Ray, S.N. (1964). Nutritive values of Indian cattle feeds and the feeding of Animals (Bull.No.25, I.C.A.R., New Delhi).

Seshan, P.A. (1932). A preliminary experiment on the digestion of fats by bullocks, Indian J.Vet.Sci., 2:333.

Sharma, G.N. (1962). Studies on growth rate and chemical composition of blood of Tharparkar calves on two levels of protein feeding, M.Sc. (A.H.) Thesis, submitted to Magadh University.

Sharma, K.M. and Talapatra, S.K. (1963). Growth response in Buffalo calves, Indian J.Dairy Sci., 17:236.

Singh, S.R., Singh, G.S. and Singh, S.N.(1963). Studies on Paragrass: Chemical composition digestibility and nutritive value of Paragrass when fed as green and hay, Ibid, 16:136.

Smith, A.M. and Reid, J.T.(1955). Use of chromic oxide as an indicator of fecal output for the purpose of determining the intake of pasture herbage by grazing cows, J.Dairy Sci.,38:515.

Snedecor, G.W. (1961). Statistical methods, Indian Ed.(Allied Pacific Private Ltd.,Bombay).

Staples, G.E. and Dinusson, W.E.(1951). A comparison of the relative accuracy between 7-day and 10-day collection periods in digestion trials, J.Animal Sci.,10:244.

Stone, P.A. and Fontenot, J.P.(1964). Effect of energy level of fattening rations on N utilisation by steers, Ibid, 28: 893.

Taneja, G.C. (1966-67). Nitrogen recycling in ruminents,(Animal Nutrition Research Workers Conference,Trichur)

Verma, B.N.(1963). Comparative growth of Tharparkar calves on Berseem and concentrates with berseem on equal nutrient intake and effect of feeding 'Terramycin Egg Formula'(Pfizer) on egg production, M.Sc.(A.H.) thesis submitted to Magadh University.

Vorotilov, M.A.(1957). Protein requirement of calves, Zivotnovodstvo No.7:48(N.A.& R.,28:Abst. 1390).

Whitelaw,F.G., Preston,T.R. and Ndumbe,R.D.(1961). The nutrition of the early weaned calf, Animal production 3:121 (N.A.& R.,32:Abst.1325).

Whiteman,J.V.,Loggins,P.F., Chambers,D. and Pope,L.S.(1954).Some sources of error in weighing steers off grass, J.Animal Sci.,13:832.

Winchester, C.F. and Ellis, N.R.(1956). Delayed growth of beef cattle, U.S.Dept.Agric.Tech.Bull.No.1159:26 (N.A.& R.,28:Abst.1415).

Winchester, C.F., Hiner, R.L. and Scarborough, V.C.(1957). Some effects on beef cattle of protein and energy restriction, J.Animal Sci., 16:426.

Witczak, F. (1957). Influence of different protein contents of feed on decomposition of fibre in the rumen of sheep, Rocz, Naukrol.,72:(B)97. (N.A.& R.,28:Abst.6188).

Woodman, H.E.(1948).Rations for Livestock Ed.11th.(Bull.No.48, Ministry of Agriculture and Fisheries, London).

****