COMPARATIVE FEED EFFICIENCY OF CROSSBRED JERSEY AND CROSSBRED BROWN SWISS CATTLE

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DECLARATION

I hereby declare that this thesis entitled **COMPARATIVE FEED EFFICIENCY OF CROSSBRED JERSEY AND CROSSBRED BROWN SWISS CATTLE** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship or other similar title of any other University or Society.

P A. Devasia

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CERTIFICATE

Certified that this thesis, entitled **COMPARATIVE FEED EFFICIENCY OF CROSSBRED JERSEY AND CROSSBRED BROWN SWISS CATTLE** is a record of research work done independently by Sri. P.A. Devasia under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship, or associateship to him.

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Dedicated to

my

Beloved Father

CONTENTS

Page No

INTRODUCTION

I. INTRODUCTION

Indian agriculture is a compact system wherein soil, animal and man are being interwoven into a highly complex interdependent and balanced system leading to a high degree of efficiency in crop, animal and human food chain Animals contribute profusely towards the well being of man by way of providing nutritious food, motive power clothing, recreation etc. Indian agriculture depends mostly on cattle to meet its requirements of draught and manure particularly in the rural areas and cattle in their turn depend very much on crop production for meeting their feed requirements.

Among the various species of animals domesticated by man, cattle have the maximum capacity to convert coarse fibrous roughages into human food stuffs efficiently and economically and as such dairying is one of the most promising rural employment programmes operating in India, majority of its beneficiaries being the landless, small and marginal farmers who form the bulk of the rural population, with a holding size of two to three animals per farm house hold of half to two acres of land. Any improvement programme for the rural masses should, therefore, include adequate dairy development projects as an integral part, the success of which, however, depends on the efficiency of animals kept for the purpose.

The efficiency of growth as well as milk production of cattle depends primarily on three cardinal principles viz. feeding, breeding and management While in the developed countries, most of the coarse grains are available for the feeding of livestock, people in almost all developing countries of the world in general and those in India in particular, have a convention of high grain consumption and therefore, competing with man, animals get practically no grains and they have to depend solely on various crop residues to meet their nutrient requirements for growth and milk production. The present trend of growth of human population suggests that more and more of land would be used for cereal production for human consumption and that the availability of feeds and fodders for cattle is likely to be reduced further, rather than being improved unless the present enormous livestock population is replaced by a lesser number of more efficient animals in the years to come.

Feed accounts for about 60 - 70 per cent of the total cost of milk production (Pradhan et al., 1975). Therefore, while considering the input-output relations for milk production, feed input to milk output is of primary concern. Feed efficiency for milk production, however, depends on the quality of feeds and also on the yielding potentiality of cows (Brody, 1968).

Appropriate breeding programmes have already been launched throughout the country towards improving the efficiency of growth as well as milk production of cattle in India since long, as a result of which better animals are now on the increase. Crossbreeding with European breeds of cattle was adopted as a quick method of augmentation of milk yield of local animals of Kerala during mid-fifties through various development projects. This programme gained momentum from 1963 onwards and the real thrust of the programme came from 1974 with Brown Swiss and Jersey being used as exotic genotypes in the southern and northern regions of the state respectively leading to a substantial increase in the crossbred population of the state.

The available literature clearly indicate that the real merit of superior germplasm can be assessed only if long term feeding experiments involving both growth and lactation studies are carried out, side by side with the breeding pro grammes. Further, it is also necessary to compare the production performances of different crossbreds under identical conditions of feeding and management in order to assess their comparative merits. In most of the earlier breeding pro grammes carried out in different parts of India, no attempt was made to com pare the performances of various crossbreds produced, with those in other parts of the country, to assess the relative merits from the point of view of feed conversion efficiency. Later on, however, a few studies have been carried out to compare the different crossbreds under identical conditions of feeding and management at National Dairy Research Institute, Karnal and at various Agri-cultural Universities of the north (Pradhan et al, 1975; Bhatnagar et al, 1975; Singh et al.,1977; Rao et al, 1979; Jadhav and Bhatnagar, 1983). Although these investigations have yielded valuable information, they are often contradictory, probably because of the heterogenic nature of the foundation stock used for the different crossbreeding programmes.

However, no systematic study has, thus far been carried out in Kerala, to compare the feed conversion efficiency of the two main types of crossbred animals available viz. Brown Swiss crosses and Jersey crosses, which together form nearly 50 per cent of the breedable cows in the state The results of simi lar studies already carried out in other parts of India and abroad are not directly applicable to Kerala in view of the fact that the overall comparative efficiency of various crossbred cattle, depends not only on their real genetic potentials for growth and milk production but also on other interacting factors like agro-climatic conditions, availability of feeds and fodders, degree of adapta tion to the approved management practices etc.

It can, therefore, be surmised that the adaptability of the type of animal most suitable to the state as assessed in terms of both biological and economic efficiencies assumes paramount importance. In a state like Kerala where the production potential of the non descript local cattle has been enhanced by cross-breeding with different exotic breeds, the need for selection and rearing of animals belonging to a particular genotype based on their performance cannot be over emphasised, particularly in view of the present tempo of crossbreeding programmes aiming at a total replacement of the entire native non descript cattle, with crossbreds of Jersey and Brown Swiss. It was therefore, considered necessary to carry out a detailed investigation to study the comparative feed conversion efficiencies of crossbred Jersey and crossbred Brown Swiss cattle in respect of growth as well as milk production.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

2.1. Present status of Agriculture and Animal Husbandry in India

2.1.1. Agro-climatic conditions.

Out of the total area of 329 million hectares of land in India, 297.3 million hectares are used for agricultural purposes, of which 11.8 million hectares forming only four per cent of the cultivated land, go to the share of pasture land (Pradhan, 1987). Different climatic zones and different types of soil in India account for most of its regional variations in Agriculture (Lensch, 1987). India is truly a land of monsoons and a large percentage of annual rain fall occurs during the south west monsoon. Rain fall and humidity vary widely from area to area, in the Khasi hills of Assam the rain fall being 425 inches and in the desert of Rajasthan five inches. According to Lensch (1987), in the north, the foot hills along the Himalayan range, with the top soil formed by erosion are cultivated intensively, and further down we have the large plains of the Ganges and its tributaries covering the major areas of agricultural production. Western India is the Domain of wheat, especially in the States of Himachal Pradesh, Punjab, Haryana and the western parts of Uttar Pradesh In the central region (U.P) besides sugarcane, wheat and rice have almost an equal share, whereas in the east (West Bengal) rice is the dominating crop with even two or three crops a year in some areas. The southern part of the north west region is covered by the desert of Thar and the steppes of Rajasthan where an extensive canal irrigation system makes cultivation possible In the dry central parts of the Deccan upland, different varieties of millets along with cotton cover the fields. In the western and eastern Ghats that belong to the zone of tropical rain forest, various plan tation crops predominate whereas in the coastal low lands, rice is the major crop.

2.1.2 Livestock population.

According to 1982 livestock census, India had 182 million heads of cattle, 62 million buffaloes, 72 million goats, 42 million sheep, 10.7 million pigs, 7.5 million horses, 1.0 million donkeys, 1.15 million camels and 150 million poultry forming 15, 51, 15, 3.6, 1.4, 1.2, 2 5, 6.7 and 2 2 per cent of the respective world population. The total livestock population of India forms 15.5 per cent of that of the world. It can be seen that during the period between 1976 and 1982 the cattle population in India had increased by 0 2 per cent per annum as against 0.5 per cent for the whole world. According to Lensch (1987), 14 - 15 per cent of the total cattle population in India are lactating cows as against 20 per cent world wide and 40 per cent in Europe. According to him, 84.2 per cent of the total cattle population of India is distributed in one third of the total 24 states, the statewise percentages being, Uttar Pradesh 15, Madhya Pradesh 14, Bihar 19 2, Maharashtra 8 8, Rajasthan 7.5, Andhrapradesh 7, West Bengal 6 5 and Tamil Nadu 6.2. The remaining 15.8 per cent is distributed over the other 16 states including Kerala Almost half of the total buffalo population is concentrated in three of the states viz. Uttar Pradesh (21 5 per cent), Andhra Pradesh (13.6 per cent) and Madhya Pradesh (10.9 per cent). The average number of cattle per 100 inhabitants in India works out to be 25.56 and in the case of buffaloes 8.7, there being 712 8 million human inhabitants distributed in about 3.3 million sq km of total area in India. The projected cattle population of India during 2000 A D. is estimated to be 185.0 million and that of buffaloes 72.0 million as against the human population of 935.3 million (Pradhan, 1987)

2.1.3. Milk production

The total annual milk production of India was 32.75 million tonnes out of which 13.8 million tonnes were produced by cattle and 18.0 million tonnes by buffaloes(Taneja and Bhat, 1987), compared to the annual world production of 437.9 million and 28.48 million tonnes respectively of cattle and buffaloe milk (Lensch, 1987). While the production of cows milk in India formed 3.15 per cent of that of the world, the production of buffalo milk in India formed 63 per cent of the same in the world, during 1982. Of the country s total milk output 42 per cent was obtained from cows and 55 per cent from the buffaloes.

According to Lensch (1987), during the period between 1974 76 and 1982 the milk yield per head of cattle increased by 2.0 kg per annum while the milk yield per buffaloe increased by 7 0 kg per annum. Thus the average milk production per head of cattle in India became 76.0 kg per annum which would be equivalent to an annual yield of 531.0 kg per lactating cow. As a result of this, the annual per capita availability of cows milk increased by 0.35 kg and that of buffalo milk by 0 4 kg during the period The annual milk availability per head of the population in India was approximately 20 kg from cows and 25 kg from buffaloes making a total of 45 kg which amounts to approximately 123 g of milk per head per day during 1982.

According to Taneja and Bhat (1987),eventhough the total annual milk production in India showed a steady increase from 17.49 million tonnes in 1951 to 32.75 million tonnes during 1982, the average daily per capita availability of milk showed a continuous decrease from 133 g in 1951 to 127 g in 1961 reaching the minimum of 114 g in 1972, evidently showing that the in crease in milk production was not to commensurate with the growth of human population. However, during the period from 1974-76 to 1982 there was an increase in the daily per capita availability of milk raising it to 126 g (Taneja and Bhat, 1987).

The projected total annual milk production of India during 1990 is estimated to be 54.0 million metric tonnes consisting of 18.1 million tonnes of cows milk and 28.5 million tonnes of buffalo milk raising the per capita availability of milk to 188.0 g per day (Pradhan, 1987). According to him, the average per capita availability of milk in India during 2000 A.D. may reach 190 g per day with a total annual milk production of 64.4 million tonnes consisting of 23.0 million tonnes of cows milk and 32.0 million tonnes of buffalo milk.

The income elasticity of demand for milk in India was estimated to be 1 25 (Kurup, 1987). According to him the demand for milk will increase by 6 25 per cent annually based on the assumption that the income is rising at an annual rate of five per cent ie, the effective demand for milk will be about 80 million metric tonnes in 2000 A.D. against the estimated production of 64.4 million tonnes (Pradhan, 1987).

2.1.4. Availability of feeds and fodders.

In India, majority of animals subsist on crop residues consisting mainly of cereal straws which are very low in their nutrient contents and the limited quantity of concentrates available is provided in the ration for milch animals. According to Taneja and Bhat (1987), the figures of available feed resources as reported by the National Commission of Agriculture (1976) indicate the magnitude of shortage in respect of concentrate, green fodder and dry fodder as 40.0, 44.0 and 38.0 per cent respectively. Considering the projected figures for 1982, the deficiencies expressed as percentages amounted to 36.0, 44.0, 37.0 and 34.0 for concentrate, fodder, energy and protein respectively (Taneja and Bhat, 1987). It has been estimated that the number of livestock available in India is far too high as compared to the carrying capacity of grass land which is therefore, gradually disappearing (Pradhan, 1987). According to him, the total annual availability of green fodder in India, however, increased from 250 million tonnes in 1980 to 300 million tonnes in 1985, while that of crop residues increased from 227 million tonnes to 266 million tonnes. Similarly the annual production of various by-products also showed an increase from 49.3 million tonnes in 1980 to 58.0 million tonnes during 1985 (Pradhan, 1987). The availabilities of green fodder, dry fodder and con centrates were estimated to be 575.0, 356.8 and 77.05 million tonnes respectively by 2000 A D. (Kurup, 1987). According to Pradhan (1987), eventhough the situation has been improving with regard to the availability of concentrates, it is unlikely that the country can achieve the ambitious projected availability of 400, 395.0 and 82.2 million tonnes respectively of green fodder, dry fodder and concentrates by 2000 A.D., as against the projected requirements of 594.8, 373 0 and 82.81 million tonnes respectively of the same, the situation being particularly alarming in respect of green fodder. The gap between availability and requirements may, however, be narrowed by 2000 A.D. on the assumption that more of food and fodder crops will be produced by the use of better technology and that livestock population will be checked by adopting several scientific measures in the cattle breeding policy of the country (Pradhan, 1987). However, taking stock of the present feed and fodder resource situation of the country, it appears rather impossible to meet the nutrient requirements of even the existing low producing cattle and buffaloes in the country. Such a situation is bound to aggravate the difficulty in the feeding of better class of livestock, such as high producing crossbred animals, towards exploiting their full genetic potentials in respect of better growth and higher milk production (Pradhan, 1987) The ever increasing human population in India and its demand for food may not allow the country to divert more land for the production of fodder and coarse grains for dairy animals. The feed and fodder resources of the country are not only limited in quantity but also in quality. Since the demand for land to be used for the production of human food will be increasing, the present helpless situation in providing adequate nutrition for cattle and buffaloes for economic milk production may continue for some time to come (Pradhan, 1987)

There exists, however, a possibility of increased food grain production to feed the increasing human population and as a consequence, the availabilities of various by-products of grains and oil seeds are also likely to be increased. Eventhough a portion of these by-products like oil cakes and brans may find export market, as is the case even at present, their availability to animals is quite likely to be increased in future. This increase may not have a significant effect on the per animal nutrient availability, as livestock population may not decrease to the extent envisaged Thus, it is quite possible that the feed resource situation may continue to remain the same as it is today with a marginal increase in the per capita availability of agro-industrial by products. Thus, according to Pradhan (1987), the projection for 2000 A.D., of about three fold increase in the production of green fodder and seven fold greater availability of concentrates for the livestock sector, is likely to remain as a theoretical exercise There is, therefore, an urgent need to re examine the situation based on our experience of the recent past in order to develop new breeding and feeding strategies towards improving the milk production in the country by increasing the availability of cattle feeds in general and green fodder in particular

2.2. Present status of Agriculture and Animal Husbandry in Kerala

Kerala which is one of the smallest states in the Indian Union, has an area of 38 85 lakh hectares with a coastal line of nearly 580 km Geographically it is situated between 8° 18 and 12° 48' north and 74° 22 and 77°-22 east longitude and occupies 1 2 per cent of the total area of the country with 3 57 per cent of its total population (Anon., 1982).

2 2.1. Agro climatic conditions.

Kerala has the dampest climate in India. The seasons in the State are mainly controlled by the two monsoons viz. the south west and the north east Topographically the state can be divided into three areas viz. high lands on the extreme east, flat low lands bordering the sea and the midlands in bet ween the two. The diversity which characterises the physical features of the state also occurs in the climatic conditions. The high lands have a cool and a bracing climate throughout the year, while the plains are hot and humid, the range of variation in temperature being 80-90°F. The average rain fall is quite high being in the neighbourhood of 96".

The soils of Kerala can be broadly divided into 5 groups viz. (1) sandy soil occurring as a narrow belt along the west coast which is deficient in all major plant nutrients such as nitrogen, phosphorus, potash and lime; poor in organic matter and slightly acidic to neutral in reaction, the impor tant crops grown being coconut and paddy; (2) alluvial soils found on the banks of rivers, rich in organic matter and the important crop is paddy; (3) laterite and red soils which cover the largest area with heavy rain fall and high temperature and are low in natural fertility; (4) peaty soils, characterised by a deep black colour, high content of organic matter and acidity, (5) forest and hill soils rich in nitrogen, highly fertile, covering about 26 per cent of the total area of the state

Kerala state has 3 5 million operational land holdings, of which over 3 0 million are below one hectare in size, the average holding size being

0.22 hectare (Menon, 1985) Only 26.0 per cent of the total area of the state is under forests and the net area sown represents 56.1 per cent. Hardly three per cent of the total land can be termed as cultivable waste Fallow lands form only about 1 8 per cent of the total area and only 10 24 per cent comes under irrigated areas. The total cropped area in the state is 25 5 lakhs hectares of which rice, pulses, oil seeds, fruits and vegetables occupy 31 0, 1.7, 24 5 and 21.0 per cent respectively.

2.2.2 Cattle wealth of Kerala.

Kerala had a total livestock population of 56.45 lakhs, of which 30.96 lakhs were cattle, 4.09 lakhs were buffaloes and 20.02 lakhs were goats and the remaining belonged to other species like sheep, pigs etc. (Anon., 1982) Majority of cattle found in the state are of non descript character However, a fairly large number of crossbred Jersey and crossbred Brown Swiss animals are available in the state. According to 1982 census, there were 14 53 lakhs of crossbred cattle forming 46.94 per cent of the total of 30.96 lakhs of cattle in the state. The density of cattle per sq km was 80 in 1982 as against 77 during the previous census. The density cf human population as per 1981 census was 655 per sq km. Thus, the pressure on land for food and other facilities is very high. The livestock population of Kerala has been showing an increasing trend ever since 1966 and according to Ananthasubramaniam and Prabhakaran (1985), there will be about 10.5 lakhs of milk yielding cows in Kerala by 2000 A D. based on the trends in the breedable cattle population and proportion of crossbreds in the state

2.2.3. Milk production in Kerala.

The productivity of cattle in Kerala, consisting mostly of a non-descript variety of poor genetic potential, is very low. The animals are very small in size and build and are stunted in growth. According to 1982 livestock census, a non-descript cow in milk,yields on an average only 1.627 kg of milk per day, while a crossbred cow gives 3.822 kg of milk per day. The daily average milk yield of a she buffalo in milk is estimated to be 3.152 kg and that of a goat in milk is 400 g (Anon., 1982). The annual production of milk in the state increased from 8.661 lakh tonnes in 1979-80 to 10.78 lakh tonnes in 1982-83 resulting in an increase in the daily per capita milk availability from 95.0 g to 114.0 g (Anon., 1986). According to Mukundan and Mathew (1983), both Jersey and Brown Swiss crosses performed equally well. Under the field conditions of Kerala, the crosses of these two exotic breeds did not vary significantly with regard to milk production, the average yield being 1500 kg per lactation period of 305 days (Mukundan and Sosamma, 1985), eventhough Jose et al. (1984) reported an average lactation yield of 2366 kg in the case of Brown Swiss half breds in the Indo-Swiss Farm, Madupetty.

2.2.4. Feeds and feeding.

Complete stall feeding is prevalent more among buffaloes than among cattle in the state. The major commodities fed to bovines as concentrates are coconut oil cake, groundnut cake, gingelly oil cake, rice bran and cottonseed, of which coconut oil cake and rice bran are wholly produced within the state, while most of the other feeds are imported from the neighbouring states.

Green fodder and paddy straw fed to animals are wholly the produce of the state. The State Department of Animal Husbandry had already started fodder development programmes in the area coming under various intensive cattle development projects in addition to two such projects now functioning under Kerala Agricultural University, one each at Vellayani and Mannuthy Further attempts are also being made at Coconut Research Station, Kayamkulam for the cultivation of fodder in the coconut gardens without any deleterious effect on the coconut trees.

Taking a moderate estimate of 3000 kg of paddy straw per hectare, the total annual yield of straw from the paddy fields in the state will be to the tune of 2.625 million tonnes, a considerable portion of which is used for pur poses other than feeding of cattle and therefore, the availability for the feeding of cattle falls much short of the actual requirement of about 6 39 million tonnes at the rate of 5 kg per head per day. Eventhough, paddy straw is gene rally known to be very poor in nutritive value, it has been reported that some of the hybrid varieties have a higher nutritive value (Devasia et al , 1976)

Inadequate and imbalanced feeding have been the major reasons for the low productivity of cattle in the state (Kunjikutty, 1969). The overall defici ency of nutrients in respect of bovine feeding in the state is estimated to be 78.0 per cent of digestible crude protein and 70.0 per cent of total digestible nutrients (Kunjikutty, 1969). According to her, apart from the stunted growth, delayed maturity and sterility, there is also heavy mortality among cattle in Kerala as a consequence of inadequate and imbalanced feeding.

2.3. Efficiency complex in animal production

2.3 1. Feed conversion efficiency.

In all agriculturally advanced countries of the world, 90.0 per cent of the coarse grains are routed through animals for the production of animal products for human consumption, eventhough major portion of the energy in grains is wasted in their conversion to animal products (Ranjhan, 1977 and Walli and Mudgal, 1987). According to them, the comparative efficiency of conversion of feed by farm animals, in terms of dry matter, protein and energy, is of great concern to scientists of all developing countries of the world

According to Kleiber (1936), dry matter intake is an excellent index of the productive aptitude, regardless of the nature of productive process within the same category of animals. There appears to be a good correlation between growth rate in the young and milk production rate in the adult, both being cor related to the same extent with the feed consumption level and dairy steers from high milking dams fatten as efficiently as beef steers; high feed consumption being the common characteristic of both (Fuller, 1930 and Winters, 1936). Leitch and Godden (1941) reported a gross dry matter efficiency of 5 7 per cent for fattening beef cattle. According to Ranjhan (1977), the efficiency of dry matter utilisation is a useful measure of feed efficiency for comparing various diets for a particular species, but it is not at all a reliable method for comparing relative efficiencies of conversions of feed into various products by different species of animals as the types of feed are dif ferent in nutritional characteristics.

In the case of ruminants, the biological value which is a useful measure of the efficiency of utilisation of protein, depends not only on its amino acid make up but also on the nature and content of various NPN substances in the feed as well as the varying microbial processes which exist in the rumen The data available in the literature on the biological values of proteins for cattle and sheep fed on different rations were summarised and general estimates arrived at are 70 for cattle and 65 for sheep (Maynard, et al., 1979).

Leitch and Godden (1941) reported a gross protein efficiency of 9 12 per cent in the case of fattening beef cattle. According to Reid (1972), the body composition of healthy animals maintained on positive energy balance is influenced by a deficiency of protein level or quality. According to him, there are important species and breed differences. The results of studies carried out by Donnelly and Hutton (1976) on calves using diets varying in protein from 16 32 per cent, at two energy levels of 4.2 and 5.2 Mcal per kg feed, illustrate the effects of different levels of protein intakes on the tissues gained. The proportion of energy gained as fat was 0.7 on 15.7 per cent protein as against 0.47 on 29.6 per cent level. Similar effects of protein intakes on the composition of gains of young pigs have been reported by Campbell (1977). Rao et al. (1979) compared the efficiency of protein conversion into milk by Brown Swiss x Sahiwal, Sahiwal and Desi cows. They found that crossbred Sahiwal and Desi cows consumed on an average 1.29, 0 97 and 0.97 kg of protein respectively per day with an average protein output of 33, 33 and 40 g per litre of milk in the respective groups The ratio between protein output and input where 24.37, 24.34 and 4.55 for the respective groups.

According to Maynard et al. (1979), the protein efficiency ratio, originally developed by Osborne et al. (1919), wherein gain in body weight per g of protein or nitrogen fed is compared, has the limitation that the protein of gain may be variable and any factor which influences the rate of growth may markedly affect the value. Ames and Brink (1977) showed that growth of lambs was highest with 197 g per day at ambient temperatures of 15 to 20°C compared to 73 g at (-)5°C and 41 g at 40°C.PER values varied from 1.36 at maximum daily gains to 0.36 and 0.2 at the lowest and highest temperatures with lowest gains respectively

According to Ranjhan (1977), Jennings' Calorie protein index" wherein production of 0.15 lb of protein (a day s allowance for an average person) is given the same weight as the production of 2600 K cal of energy (a day s allowance for energy), is a useful measure of efficiency of protein utilisation. Measured on this basis, he estimated the amounts of feed units required to produce one unit of calorie protein index for the production of milk, pork, egg, chicken, beef and lambs to be 6.5, 9.2, 10.7, 12.0, 41.3 and 51.7 respectively showing that milk production is the most efficient one.

According to Brody (1968), the energetic efficiency of utilisation of feed is the ratio of the desired form of output energy like milk, meat, egg, wool, work and so on to the given form of input energy like gross energy, digestible energy, metabolisable energy or net energy While gross or apparent or crude efficiency is the percentage of energy in the given feed category, inclusive of maintenance, recovered in the desired product, net or real efficiency is the percentage of the energy in the given feed category exclusive of maintenance recovered in the desired product.

2.3.2. Efficiency of growth.

The limited studies carried out (Brody, 1968) on the energetic efficiency of embryonic growth of chick, silk worm and fish which are particularly suited for the purpose, on account of the complete control of the organism, the definiteness of the nature of the nutrients and the convenient relative isolation from complicating environment, revealed that the gross efficiency of embryonic growth is of the order of 60 to 65 per cent and that there is no significant difference in gross efficiency inspite of the size and species differences. Needham (1931) showed that the gross efficiency increases from 43 to 67 per cent from third to 19th day of incubation in chick.

There appears to be some controversy regarding the nature of work energy of morphogenesis and growth. Tangle's research ignored the possibility that it may be structured in the tissues as configurational or potential energy analogous to the energy stored in winding a spring or charging a battery but on the contrary, he assumed that the energy consumed for the work of growth and development is expended as heat analogous to that is utilised for rearranging the chairs in a room, wherein the potential energy of the chairs or room is not increased.(Brody, 1968).

From a review of the literature on the hypothetical organisational energy, Needham (1931) concluded that it amounts to four per cent of growth transaction. It has been reported that during the first few days of incubation of chick embryo, heat is absorbed rather than dissipated or at any rate there was a low heat production in comparison to oxygen consumption (Brody, 1968). This apparently 'missing heat" may be due to the endothermic reaction or due to the retention of organisation energy in the tissues (Mayerhof, 1911 and Terroine and Wurmser, 1922) Rapkine (1929) observed unusually high respiratory quotient which he interpreted as suggestive of synthesis by coupled oxidation-reduction reactions as compared to simple combustion The consensus of opinion is that much of the energy expended for organisation is dissipated in the form of heat, rather than being structured into the organism (Tyler, 1933; Kibler, 1942; Collier, 1942 and Brody, 1968) This can be inferred partly from the fact that unlike the structured energy in a battery or spring, the energy of differentiation is not reversible, the differentiation process itself being not reversible

According to Rubner (1908), the amount of energy required for doubling the birth weight is the same per kg in all species except man. According to him, the net energetic efficiency of early postnatal growth works out to be 35 0 per cent, taking the combustion value of gain as 866 Kcal per kg. Lusk (1928) reported that pigs retain 20.0 per cent of their dietary calories during the first doubling of body weight taking combustion value of gain as 866 Kcal per kg. According to Kleiber (1935), the ratio of feed consumption to basal met bolism and maintenance is independent of body weight and therefore, the exces feed that may go for production process is independent of body weight. Rochfor (1936) observed that 820 lb cattle and 114 lb sheep made the same gains per unit feed consumed during a 60 days period. Though, the daily absolute gains were 2.5 lbs in cattle and one third lb in sheep, both required 1040 lbs of feed to gain 100 lbs of weight. Similarly, rabbits and cattle are reported to be equally efficient converters of feed into live weight, presumably at equiva lent physiologic age (Kleiber et al., 1926). Estimates on the gross energetic efficiency of Jersey cattle by Brody (1968) indicate an efficiency near 35.0 per cent for doubling birth weight with a decline to five per cent at the age of two years assuming an energy value of four Kcal per g of TDN and two Kcal per g of weight gain. Similarly, he found that the gross energetic efficiency of growth of Holstein cattle falls from early 35 per cent to 10 per cent at 9th month of age. Leitch and Godden (1941) reported gross energetic efficiency of 16 per cent in the case of fattening beef cattle. Studies carried out by Ritzman and Colovos (1943) in growing dairy cattle have shown that they retain food energy more efficiently than the adults and that their superiority declines as they grow older. According to Blaxter (1969), the efficiency with which the energy of milk is used to promote gains, is very high in very young calves once the maintenance needs are met. He found that between 80 and 85 per cent of milk energy is retained as fat and protein.

2.3.3. Efficiency of milk production.

Brody (1968) reported that the gross efficiency of milk production of dairy cows vary from 28-34 per cent using data obtained from 368 dairy cows weighing from 1000 to 1300 lbs, producing 28-50 lbs of F.C.M. consuming 17 28 lbs of TDN per day. In other words, one third of the TDN energy consumed by the superior cows was recovered in the milk. According to him, the gross energetic efficiency of milk production of 'good" dairy cows is of the same order as the gross efficiency of early postnatal growth on "good' diets viz about 30 per cent Forbes and Le Roy Voris (1932) observed a gross efficiency of 18-23 per cent of milk production.

From a review of the available literature, Brody (1968) concluded that the gross efficiency of milk production with respect to T.D.N consumed may rise up to 50 per cent at biologic limit, in the highest producing champions. Following the physiologist s I.Q. concept, it is said that if the gross efficiency of milk production of the "average good' cow is 30 per cent and if a given champion cow s gross efficiency is 48 per cent, the L Q. (lactation quotient) of the champion cow is 48/30% 160. Thus, according to him, a cow having a L.Q of 166 (50/30% 166) is a "lactational genius' just as a man having an I.Q.of 166 is an intellectual genius'.

It is, however, evident that the gross energetic efficiency of milk secretion, which carries the burden of the maintenance cost of the cow, can never be as great as the net efficiency As production increases the maintenance tax per unit of milk produced becomes less and less, and therefore, the gross efficiency approaches nearer and nearer to the net efficiency level, but at decreasing increments in accordance with the law of diminishing returns. Since the net efficiency of milk production is of the order of 60 per cent, the gross efficiency can never reach 60 per cent, but it may approach 50 per cent

2 3 4. Factors influencing efficiency of animal production.

(a). Body size.

From the studies on the effect of body weight on milk production in Holstein x Sindhi crossbreds, Singh and Desai (1966) concluded that a partial regression of milk yield on body weight is independent of age. They indicated an optimum body weight of 751 to 850 lbs for most efficient milk production in these crosses. Berruccos and Robles (1966) reported a correlation coefficient of 0.076 for Holstein Friesian cows between mean body weight and 360 day lactation and mean daily milk yield.

According to Brody (1968), the gross energetic efficiency of milk production or "dairy merit" is virtually the same in rats, goats, humans and cattle, the differences of opinion concerning the influence of body size on milk production are due to differences in the reference bases employed. According to him, the observation that small dairy cows are frequently more efficient than large ones, is not due to body size as such, but because the basis for selection has been the production per cow. To stay in the herd, the small cow has to produce nearly as much as the big ones. If the small cow produces as much as the big cows, she is more efficient because she expends less of her food for maintenance. From an analysis of lactation data of cattle, goats, rats and humans, Brody (1968) concluded that body size as such does not influence the energetic efficiency of milk production and that other conditions being equal, small and large animals convert the same percentage of feed energy into milk energy. Miller et al. (1973) observed that body weights at the beginning and end of lactations were better suited for predicting the milk yield, feed intake and feed efficiency Higher body weights in the beginning of lactations were associated with increased milk yield and higher weights at the end of lactations with low milk yield.

(b). Specific dynamic action

Studies carried out by Benedict and Ritzman (1927) and Ritzman and Benedict (1938) have shown that the heat increment appeared unexpectedly early and is large in the case of dairy cattle. According to them, the anaero bic fermentation in the rumen results in early formation and absorption of short-chain fatty acids such as butyric, which exert a heat stimulating effect of the Voit variety prior to the protein effect. According to Brody (1968), the heat increment of feeding in large animals especially in ruminants fed dietary imbalanced roughage, is huge. This heat increment could be reduced or perhaps abolished by feeding at appropriate intervals a perfectly balanced diet, as reported by Richardson and Mason (1923) But, quite often farm animals are not kept for maintenance alone, but also for production, and they are never fed proteins of 100 per cent biological value in particular or perfectly balanced rations with regard to needs in general. Moreover, the handling of bulky farm feeds, especially by ruminants, involves other energy expenses than those investigated by Rubner (1908), Terroine and Wurmzer (1922), Lusk (1928) and others on dogs, rats and frogs The heat increment of feeding in farm animals is, therefore large forming about 20 per cent of the gross energy of the good customary balanced mixed rations and it will be much higher when fed poor roughage alone (Brody, 1968) According to him, the large heat increment is an effective protection against cold and this explains, in part, the ease of wintering livestock especially ruminants on a poor hay diet in cold countries. By the same token, the specific dynamic action is a serious burden in hot weather, popularly expressed by saying that hay feeding, especially with protein rich feeds burns out' the animal, and one of the major problems of animal husbandry is to keep down the summer body temperature in productive animals and thus maintain their productivity

(c). Plane of nutrition.

Brody (1968) found that the greatest increase in energy loss with increasing plane of nutrition was due to the S D A which increases from about three per cent at 0.5 maintenance ration to about 20 per cent at 3 times the maintenance ration. According to Coppock et al. (1964), the efficiency of feed conversion in milk production was found to be significantly affected by the composition of the ration. They calculated the effect of hay to grain ratio, on utilisation of metabolisable energy for milk production. More metabolisable energy was required for milk production from the 100 per cent alfalfa ration than from the alfalfa-concentrate rations. The mean efficiencies of converting the available metabolisable energy to milk were 65, 61 and 54 per cent respectively for rations containing 50, 75 and 100 per cent alfalfa hay rations. Gracek (1966) reported that the milk yield was higher when the ratios of concentrate to roughage were 1:1.62 and 1:3.8 than when it was 1.14.9. The gross efficiency of energy utilisation was found to be 26.8 for an all roughage ration with meadow grass, rice straw and corn silage and 27.7 for a ration consisting of half of the above roughages plus concentrates (Hazhizume et al., 1965). It has been reported that the conversion of nutrients to milk is more efficient than their first con version into body tissues and then into milk and that feed conversion efficiency is maximum in lactating cows when fed at a level that brings about minimum weight gain (Flatt and Coppock, 1965 and Flatt et al., 1967). Panaytove and Michev (1970) reported that cows with moderate milk production showed a higher efficiency of feed utilisation when fed semi concentrates and the increase in concentrate allowance did not raise the efficiency in these animals. Paulicks and Kirchgessner (1986) found that generally, a protein restriction leads to a reduction of milk yield which amounts to 0.9 kg F.C.M. with every per cent of crude protein less in the feed. Estimates of mean efficiency of utilisation of M.E. for lactation made on a weekly basis, were reported to be 0.48 and 0.52 respectively for heifers fed on either good or average quality grass silage ad lib. and 0.48, 0.52 and 0.52 respectively for those given low, medium and high levels of concentrates (Phipps et al., 1987).

(d) Level of production.

According to Brody (1968), the casual mechanism actuating the decline in milk increments with successive units of concentrate intake in the same animal is of a complex nature. According to him, first there is a decline in feed utilisation, in terms of net energy per unit feed with increasing feed intake. Secondly, there may be a decline in the energetic efficiency of the entire milk producing mechanism with increasing lactation rate above a certain production level similar to the decline in the energetic efficiency of an automobile with increasing driving speed above about 30 miles an hour. Brody (1968) concluded that increased T.D.N. consumption, brought about by increased grain allowance, tends to increase the milk yield, but at decreasing increments with successive feed units in accordance with the principle of diminishing increments. According to Kroll et al. (1987), it is not necessary to adopt different feeding systems according to the potential yield of the cow and cows could be given rather lower energy diets within the range offered without loss of efficiency. This assumes importance in a situation wherein economic efficiency counts more than the biological efficiency.

(e) Weather.

Animals wintering outdoors respond to approaching cold weather by developing highly insulating coats of fur and subcutaneous fat (Mayer and Nichita, 1929). By driving the blood from the surface on declining temperature, the blood is kept from cooling and the skin becomes highly nonconductive to heat. Moreover, incidental to their productive or even maintenance process, farm animals consume large quantities of feed associated with high heat production, thus keeping the animal warm in cold weather and making it unnecessary for the body to increase the oxidation for the maintenance of normal body temperature. It has been reported (Dice, 1940) that dairy cattle wintered outdoors (9° to 27°F) produced as well, as when conventionally housed and the feed cost for maintenance was not increased by the lower outdoor temperature According to Brody (1968), eventhough the "critical" temperature of farm animals is reported to be 60 70°F under basal metabolism conditions (Mitchell and Haines, 1927; Deighton, 1929 and Mayer and Nichita, 1929), it is probably without any significance for normal farm animals under normal management conditions.

Marked depressing effect of high environmental temperature on feed consumption and feed utilisation of dairy cattle was observed by Kleiber and Dougherty,1934. According to Brody (1968), an increase in environmental temperature from 60 to 95°F resulted in a decline in daily milk yield (from 27 to 17 lbs), casein (from 2.1 to 1.8 per cent) and S.N.F. (from 8.1 to 7.6 per cent). The Zebu or Brahman cattle, Bos indicus, stand heat better than the European cattle, Bos taurus (Kelley, 1932). According to Broucek et al.(1986), when cows were kept at 33-34°C and 40-60 per cent relative humidity, milk yield decreased by 5.2 per cent on the first day, eight per cent on the second day and 16 5 per cent on the third day. Corresponding decreases in hay intakes were 10, 21 and 37 per cent and silage intake was down by 16 per cent by third day. According to Hegade and Bhatnagar (1986), the longest lactation period and the highest lactation milk yield was with calvings in November-April and highest daily milk yield was with calvings in August - January in the case of Karan Swiss cows. Kotilinga Reddy et al. (1987) also observed that season of calving is an important environmental factor determining the quantity of milk produced, lactation length, dry period and calving interval. Ludri and Singh (1987) reported that Karan Fries cows are comparatively less heat tolerant than Karan Swiss cows.

(f) Genetic potential.

There are 26 well defined breeds of cattle in India, which constitute only about 18 per cent of the total cattle population, while about 78 per cent belong to non-descript type, which are late maturing and poor producing (Taneja and Bhat, 1987). According to them, these local cattle are, however, well adapted and resistant to various endemic diseases and they endure hot environment better than all temperate breeds even though they tend to alleviate heat stress by decreasing milk production (McGlothlen, 1987). But the possibility of replacement of these low producing native cattle with high yield ing temperate genotypes does not seem to be practicable in view of the taboo on cow slaughter, non-availability of temperate cattle in sufficient numbers and problems of their survivability and adaptability in the tropical environment. They found that the performance of temperate genotypes in tropical environment was 30-40 per cent lower than that in the countries of their origin.

The major strategy for the development of indigenous cattle for milk production efficiency has, therefore, been crossbreeding with superior European dairy breeds. A two to three fold increase in milk production in crossbreeds over the indigenous breeds was observed depending upon the inputs, level of husbandry practices especially feeding and environment. The milk yields of various crossbreeds in first lactation, varied between 1500 and 3000 kg (Tajena and Bhat, 1987). According to them, the crossbreds under challenge feeding had given 40 to 60 per cent higher milk yield. McDowell (1985) found that the crossbreds show some heterosis for milk production and that they are markedly superior to either the local or exotic breeds for reproduction and survivability.

According to Taneja and Bhat (1987), the exotic inheritance around 50 per cent is most ideal for growth, reproduction and milk production and the yield in higher crosses fall short of the theoretical expectations. The grading up, therefore, to a total replacement of genes, will not lead to higher production in Indian cattle (Taneja et al., 1979, Rao and Taneja, 1982 and Taneja and Bhat, 1987). Taneja and Bhat (1987) found that the decline in milk yield from

F1 to F2 generations on account of inter-se mating among F1 crossbreds is small and the large decline reported to have been observed during the course of the experiments carried out at Karnal (Bhatnagar et al., 1975) and Sri Lanka (Bhuvanendran and Mahadevan, 1979) was due to the poor quality of the crossbred bulls used. According to McDowell (1985), if the crossbred animals are mated to their own kind, there is large drop in production, representing the loss of half of the heterosis plus not having the select sire possible with the temperate breeds. Back crossing to the local stock, however, gives healthy animals but will result in a large decrease in production.

According to McGlothlen (1987), the only method of breeding which will avoid the loss of heterosis in the F1 crossbreds seems to be mating them with a different crossbred to get a four breed mix. This prevents most of the hete rosis loss and the four breed mix so obtained can be bred within the mix with little deterioration as long as the population is large enough to avoid inbreeding problems (Trail and Gregory, 1981 and Trail, 1986). The selection of the four breeds to be used is a matter of some dispute, the answer depending to some extent on where and how they are to be used. Of the various temperate breeds already introduced to india and which are now being used for crossbreed ing programmes, Brown Swiss is known for hardiness and capability of rapid move ment of hills, quickness of foot and pasture adaptability in addition to better milk yield; Jersey for small size, higher feed efficiency, easy managability and higher fat content of milk, besides higher milk yield; Red Dane for high milk yield and brick red colour and Holstein for the two most prized qualities of fast growth and large quantity of fluid milk. In a four breed mix, genes for early maturity, high milk yield and efficiency of milk production are made available from the European breeds and those for disease resistance and heat tolerance are contributed by the local genotypes. According to McGlothlen (1987), Holstein crosses tend to be the best for milk yield, Red Danish crosses for milk solids, Jersey crosses for reproduction and Brown Swiss for draft and milk (dual purpose).

Some new breeds like Sunandini, Jersind and Taylor have already been evolved using the crossbred populations as the foundation base, though none of them is based on four breeds contributing equally (Taneja and Bhat, 1987). The Jamaica Hope is mostly Jersey with some Sahiwal and a little Holstein. The Australian Friesian Sahiwal is half Sahiwal and half Friesian. The Australian Milking Zebu is part Jersey, part Friesian, part Sahiwal and part Red Sindhi, but in varying proportions. Several other synthetic breeds like Karan Swiss and Karan Fries which are well known are in the process of being developed. In addition, five crossbred genotypes (two and three breed crosses) with Hariana, Gir and Ongole as the indigenous breeds are under performance testing at five locations in the country (Taneja and Bhat, 1987). The three breed crosses with 75 per cent exotic inheritance from two exotic breeds have shown high potential for growth, reproduction and production under optimum input conditions and are under further testing. The work on their nutritional requirements and adaptations is in progress.

Cross breeding with European breeds of cattle was adapted as a quick method of augmentation of milk production efficiency of local non-descript cattle of Kerala during mid fifties on a small scale. This programme gained momentum during 1963, when crossbreeding with Swiss Brown was started under the Indo Swiss Project, with the assistance of Swiss Government at Madupetty. While Brown Swiss was being used in the Southern region of the state, Jersey was being used in the Northern parts. Thomas et al. (1987) reported an average first lactation 305 day milk yield of 1476+114.2 and 1513±130.2 litres respectively for local type crossbred cows in Kerala with 50 and 62.5 per cent Brown Swiss blood. According to Sosamma (1987), as a result of the crossbreeding programme in operation in the State since 1956, Kerala has at present about 7 lakhs of crossbreds with either Jersey or Brown Swiss inheritance, out of a total of about 14 lakhs of breedable cows. According to her, crossbreeding with Jersey and Swiss Brown bulls has increased the average milk production to about 1500 kg per cow per lactation period of 305 days. She reported that both Jersey and Swiss Brown crosses were persistent in their milk production and that both 50 and 62.5 per cent crosses did not differ significantly in their first lactation milk production. She also reported that Swiss Brown crosses of Mavelikkara had higher production compared to those of Kattappana. As the bulls used were the same in both the places, the difference could be due to the difference in the kind of Zebu, the local cows of Mavelikkara being graded Sindhi.

2.3.5. Comparative efficiency of different crossbred cattle.

The efficiency of utilisation of feed depends on the rate of growth in growing and level of production in lactating animals as the feed required for unit growth or milk production decreases with higher rate of growth or higher level of milk production, the input cost being much more towards feeding the animal for maintenance (Pradhan, et al., 1975; Bhatnagar, et al., 1975 and Pradhan, 1987). The differences in the rate of growth or level of production, if any, between different genetic groups of crossbreds depend on the genetic potentials.

(a). Efficiency of growth among different crossbred genotypes.

Exotic cattle are generally more efficient in converting feed into body weight and crossbreds are intermediate in this respect (Ledger, et al., 1970). The fact that differences due to genetic groups were significant for weight at birth was shown by Naidu and Desai (1965); Taneja and Bhat (1970); Pandey (1971); Murthy (1974) and Chauhan, et al. (1975). From the studies carried out in Brown Swiss and Sahiwal Red Sindhi crossbreds known as Karan Swiss, with half exotic inheritance, Bhatnagar, et al. (1975) showed that their birth weight of 26-27 kg was 20-30 per cent more than their zebu herd mates and that they had a daily weight gain of 510 g per day upto 6 months of age when they weighed on an average 120 kg as against 390 g and 91 kg and 344 g and 82 kg respectively in the case of Sahiwal and Red Sindhi. During 9-12 months of age they observed a daily gain of 250 g for crossbreds (F1) as against 200 g for Sahiwal. Chawla and Mishra (1976) concluded from their studies that female calves of Brown Swiss x Sahiwal were significantly heavier at birth (25.5+0.22 kg) than Friesian x Sahiwal (23.45+0.07 kg) or purebred Sahiwal (21.03+0.13 kg).

Hollon et al. (1972) and Bhat and Singh (1978) reported significantly higher growth rate in Holstein crosses than in Jersey and Brown Swiss crosses with zebu. They observed maximum growth rate during the 7th and 9th month in the post-weaning period in the case of Jersey and Holstein crosses respectively.

Branton, et al. (1961); Patel (1978) and Rao and Nagarcenkar (1979), however, reported maximum growth rate between third and sixth month of age while Parekh et al. (1976) reported maximum growth rate between sixth and 12th month of age in different crossbred calves. The concensus of opinion seems to be that the crossbreds with various levels of Brown Swiss and Holstein Friesian inheritance show maximum growth rate during fourth to sixth month of age (McDowell, et al., 1959; Mudgal and Ray, 1965; Parija, 1972 and Hingane, 1975). Chawla and Mishra (1981) studied in detail the role of Brown Swiss and Holstein Friesian genes on growth rate using data on 689 Sahiwal, 639 Brown Swiss x Sahiwal and 3802 Holstein Friesian x Sahiwal crossbreds and found that body weight at various intervals of age had curvilinear relationship with the increase of Holstein Friesian inheritance from 1/8 to 7/8, except at birth and at two months of age when it was linear. Superiority of body weight gain by Brown Swiss gene infusion over sahiwal females measured in percentage was 16.9 (F2 and F3) to 25.8 (1/2, F1) at 12 months of age and 12.2 (F2 and F3) to 17.6 (3/4) at first calving. Corresponding values for Holstein Friesian grades were 15.1 (1/8) to 25.7 (4/8) and 3.3 (1/8) to 8.7 (4/8) respectively. According to them, crossbreds with various levels of Brown Swiss and Holstein Friesian inheritance showed maximum growth rate during 4-6 months of age, followed by steep fall in growth rate during 6 9 months, which further declined in between 15 and 18 months of age. Patel, et al. (1985) found that Holstein crossbred calves were heavier at birth and that they remained consistently heavier than the Jersey crosses upto one year. From a detailed study carried out, Vij and Basu (1986) concluded that 3/4th crosses of Sahiwal and Tharparkar with Holstein, Brown

Swiss and Jersey had the highest (27.9 kg) and the purebreds, the lowest (17.88 kg) body weight at birth.

The age at calving in the case of Brown Swiss (F1) crosses was reported to be 29.6 months as against 38.7 months in Sahiwal, the latter being lower than most of the other Indian breeds of cattle (Bhatnagar et al., 1975). From an analysis of the data collected from the crossbreeding experiments at National Dairy Research Institute, Karnal, involving the native breeds, Sahiwal and Tharparkar and three exotic breeds, Holstein, Brown Swiss and Jersey producing 2-, 3- and 4 breed crosses, Vij and Basu (1986) found that the body weights at 6, 12, 18 and 24 months were maximum in half breds followed by those in 3/4, 3- breed and 2-way crosses.

Thomas and Razdan (1973) observed that Brown Swiss Sahiwal crossbred bull calves of 12-18 months of age consumed significantly less D.M. and T.D.N. per day per 100 kg body weight as compared to Sahiwal bull calves. Keshavamurthy (1973) observed a gross efficiency of feed conversion of 25 per cent and 14 per cent in the case of crossbreds and Sahiwal respectively during their growth with a gross energy intake of 23455 Kcal and 22516 Kcal respectively. According to Bhatnagar et al. (1975) the gross energy required for one g gain in body weight between 9 and 12 months of age was 48.5 and 58.7 Kcal in crossbred and Sahiwal calves respectively. According to them, crossbred calves of about two years of age consumed 4.88+0.02 kg of D.M. per 100 kg body weight, while Sahiwal calves of the same age consumed 4.71+0.02 kg of D.M. with a fortnightly weight gain of 9.05+0 42 and 4.88+0.82 kg respectively. They worked out the gross energy utilisation per g body weight gain as 31.49+7.67 Kcal for crossbred calves and 62.59+12.08 Kcal for Sahiwal calves using data obtained for seven fortnights. According to them, the D.M. and TDN consumptions of crossbred bull calves of 1.5 to 2.5 years of age were 3.47 and 2.13 kg per 100 kg metabolic body weight ($W_{kg}^{0.73}$) as against 3.54 and 2.18 kg respectively in Sahiwal bull calves of the same age. Singh and Bhat (1979), from their studies on different crossbreds (Hariana x Holstein Friesian, Hariana x Brown Swiss, Hariana x Jersey) concluded that there were no significant differences between the different genetic groups in respect of digestibilities of nutrients, growth performance and efficiency of feed utilisation. Virk et al. (1981) compared half breds of Holstein Friesian, Brown Swiss and Jersey with Hariana and 3/4th bred animals (with two breeds of exotic inheritance) of 7-14 months of age and concluded that there were no significant differences between the different genetic groups in regard to nutrient intake, digestion coefficient of organic nutrients, energetic efficiency and growth performance.

Comparative studies on growth rate and feed consumption, carried out on different Kankrej crosses (Kankrej x Jersey F1 and Kankrej x Holstein Friesian F2) revealed that the average daily dry matter intake of Jersey crosses were higher than that of Holstein crosses (Panda and Sadhu, 1973; Singh, 1974 and Patel, 1978. Patel et al. (1985) reported that the average daily dry matter intake per 100 kg body weight of Jersey (3.2+0.08 kg) was significantly higher than that of Holstein crosses (2.9+0.06 kg), eventhough the average dry matter intake per kg body weight gain was not significantly dif ferent. As the age increased, the dry matter required per kg body weight gain also increased. The results of feeding experiments carried out by Kurar et al.

(1987) in crossbred male calves (Holstein Friesian x Sahiwal) showed that there was no significant effect of protein or energy or interaction of protein and energy on the energy loss through faeces, urine and methane.

(b). Efficiency of milk production among different crossbred genotypes.

Eventhough extensive crossbreeding of Indian cattle with high yielding exotic bulls was started during early sixties, attempts to assess the milk production efficiency of crossbreds produced, were made during early seventies only. According to Wagan (1971), crossbred Brown Swiss cows showed nearly six per cent higher feed conversion efficiency than the Sahiwal cows. Patle (1973) reported that the energy requirements for maitenance of lactating cross bred cows were higher than those in the current standards used in the country and, therefore, they should be fed with higher levels of energy for maintenance and for optimum milk production. He also observed a higher efficiency of feed utilisation in crossbred cows during early lactation. Ram and Singh (1974) reported that the cost of milk production per litre during 1972 73 at Karnal price was 79 paise in crossbreds as against Rs.1.21 in Sahiwal when the expenditure on feed, replacement, labour, supervision, Veterinary and other miscellaneous costs were taken into account and the income from dung was deducted. From an analysis of the data on Brown Swiss crosses (Karan Swiss) at Karnal, Bhatnagar et al. (1975) reported that the fodder consumption in crossbred lactating cows varied from three to five per cent of body weight on dry matter basis when fed ad lib. Data over a lactation period of 305 days showed that the average gross energetic efficiency of milk production was 23.18+1.03 for

Sahiwal cows (Bhatnagar et al., 1975). Crossbreds and Sahiwal cows consumed daily on an average 10.42+0.46 and 7.68±0.76 kg T D N. producing 12.49±0 51 kg and 6.62±0.26 kg of four per cent fat corrected milk respectively. He found that the fat and S.N.F. percentages were not significantly different for different crossbreeds. The first generation of Brown Swiss crossbreds gave an average fat percentage of 4.8 as against 4.9 in Sahiwal cows, second generation (F2) half breds and 3/4th Brown Swiss Zebu crossbreds, average percentage of S.N.F being 9.1 in all the groups.

The first systematic study on the comparative feed conversion efficiency of some of the crossbreds in India was carried out by Pradhan et al. (1975) using five best lactating cows each from half Holstein x half Hariana, half Brown Swiss x half Hariana, half Red Dane x half Hariana, half Jersey x half Hariana and pure Hariana cows for a period of 12 weeks. They found that Holstein crossbred cows were more efficient in milk production as compared to Brown Swiss, Red Dane and Jersey crosses and pure Hariana cows, the average F.C.M. yields being 12.1, 8.8, 9.7, 9.3 and 6.4 kg respectively per day. Although, the nutrients consumed by the Holstein crosses were more than those of other crosses, the efficiency of milk production in these cows was highest with lowest cost of milk production. Bhatnagar et al. (1975) reported gross efficiencies of 29.14 and 28.23 and net efficiencies of 51.2 and 51.13 respectively in the case of crossbred Brown Swiss cows and Sahiwal cows. The total butter fat production in crossbreds and Sahiwal cows were 116.5 and 79.36 kg respectively during the lactation period. Rao and Nagarcenkar (1976) from their studies on the efficiency of milk production of crossbred cattle found that half breds are the best from the point of view of milk production as well as efficiency of milk production. They concluded that Jersey breed is the best to develop high yielding and efficient dairy cattle for the north western states of the Indogangetic plains.

According to Singh et al. (1977), the higher efficiency of Holstein cross breds reported by Pradhan et al. (1975) was due to the fact that the Holstein cows used in their study were higher producers than the other genetic groups as he used the highest producers available in each. They, therefore, carried out another systematic study using five animals each from half Holstein x half Hariana, half Brown Swiss x half Hariana and half Jersey x half Hariana producing almost equal quantities of milk, for a period of 12 weeks. They found that cows of all genetic groups gained significantly more body weight than those in crossbred Jersey group. The average dry matter consumption (kg per day) and F.C.M yield (kg per day) in respect of Holstein, Brown Swiss and Jersey crosses were 12.66 and 10.66; 11.97 and 9.14 and 12.37 and 12.05 respectively. Although, the total D C P and T D N consumptions were not markedly different in the three groups, the D C P and T D N consumptions per kg of F.C.M. produced were lowest in Jersey crosses and highest in Brown Swiss crosses. The cost of milk production also showed a similar trend. Due to the higher percentage of fat, Jersey crosses produced significantly higher quantity of F.C.M. than the other two genetic groups and hence proved to be more efficient as an economic milk producer.

Jadhav and Bhatnagar (1983) compared the dairy merits, in terms of per centage of consumed T D.N. energy which is converted into milk (FCM) energy, of various crossbred cows produced by mating Holstein, Brown Swiss and Jersey bulls with Sahiwal and Tharparkar cows. They found that the lactation dairy merits for Holstein crosses were significantly higher (28.82+0.25 for Holstein x Tharparkar and 28.76±0.53 for Holstein x Sahiwal) than those for Brown Swiss crosses (26.59±0.14 for Brown Swiss x Sahiwal and 26 01+0.14 for Brown Swiss x Tharparkar) as well as Jersey crosses (26.2+0.33 for Jersey x Tharparkar). According to them, selection on the basis of dairy merit may be advantageous over absolute milk yield because it takes into consideration the general adaptability, inherent capacity for milk production and efficiency of feed utilisation. Reddy and Basu (1985) reported that Holstein sired crosses performed better than the Sahiwal sired crosses in respect of age at first calving, first lactation milk yield, milk yield per day of first lactation, days dry per cent, herd life, life time milk yield, milk yield per day of life, first lactation profit, profit per day of first lactation, life time profit and profit per day of herd life.

Jadhav and Bhatnagar (1986) carried out a detailed investigation on income over feed cost, income over feed cost per day of calving interval and income over feed cost per unit of feed cost among five genetic groups of crossbred cows at Karnal. They found that Holstein x Tharparkar were better for income over feed cost than Holstein x Sahiwal, Brown Swiss x Tharparkar, Brown Swiss x Sahiwal and Jersey x Tharparkar. Jersey x Tharparkar cows tended to be relatively better over Brown Swiss x Tharparkar, Brown Swiss x Sahiwal, though the differences were not significant. Tharparkar cows had better combining ability with both Holstein and Brown Swiss breeds than Sahiwal cows for all the measures of income over feed costs.

Vij and Basu (1986) compared the performance of half, three fourth, three-breed and two way crosses between exotic and native breeds to study the role of native dam breeds in influencing the performances of the cross bred progeny. They found that the progeny of Tharparkar dams were superior to that of Sahiwal dams in respect of weight at first calving, age at first calving, first lactation milk yield and dry period. According to them, Holstein sires significantly influenced lactation length and calving interval. The effect of the breed of sire in respect of most of the production traits was lesser than the breed of dam effect. They concluded that the maternal effects could be a possible cause of this discrepancy. The interaction between the breed of sire and the breed of dam was, however, not significant except for weight at first calving.

Thomas et al. (1987) studied the effect of genetic group, sire, year of calving, age at first calving etc. of 50 per cent and 62.5 per cent Brown Swiss crosses in Kerala and found that heifers calving below 36 months of age had higher production of 1667.5+126.6 litres compared to 1499.8+113.4 and 1307 2±127.7 for those calved between 36 and 47.9; and 48 and 59.9 months respectively, probably because of better management by some farmers. They concluded that 50 per cent and 62.5 per cent crosses did not differ significantly in this respect.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

The experiments carried out during the course of the present investigation are described in two parts. In part I, the experiments carried out to assess the comparative feed conversion efficiencies of crossbred Jersey and crossbred Brown Swiss cattle for growth in terms of feed consumption, weight gain, body measurements, blood constituents, digestion coefficients of nutrients, nitrogen retention and energy utilisation, using half bred heifers belonging to the two genetic groups, are described. In part II, the investigations involving comparative evaluation of the feed conversion efficiencies of crossbred Jersey and crossbred Brown Swiss cows for milk production in terms of maintenance of body weight, feed consumption, total milk yield, F.C.M. yield, compositon of milk, blood constituents, digestion coefficients of nutrients, nitrogen balance and energy balance, using half bred cows of the two genetic groups are described.

Part I

3.1. Growth study

Two groups of eight heifer calves each belonging to the two genetic groups of crossbred Jersey and crossbred Brown Swiss respectively, were arranged in a completely randomised design and were maintained under identical conditions of housing, feeding and management for a total period of 28 fortnights when all of them had attained sexual maturity. Records of daily intake of concentrate, roughage and water were maintained. Fortnightly data on body weight and monthly data on body measurements and haematological values were gathered. Digestion-cum balance trials were carried out during the middle as well as at the end of the experimental period.

3.1.1. Animals.

Healthy female calves of 5-11 months of age belonging to the two genetic groups of half bred Jersey (Group A) and half bred Brown Swiss (group B) obtained from the University Livestock Farms at Thumburmuzhi, Thiruvazhamkunnu and Mannuthy formed the experimental subjects. Animals were selected in such a way that the two groups were essentially similar in respect of their average age and body weight.

3.1.2. Housing and management.

All the 16 animals were housed in a single shed in individual metabolism stalls arranged in two rows following the tail to tail system. Each stall had individual mangers with masonry side wall upto a height of one metre on either side of the mangers as well as standings in order to restrict the movements of animals in their standing space and to prevent them from getting at the feed of the adjacent animals on either side. Stall feeding was practised through out the period of the experiment. Animals were cleaned every day in the morning before 9 a.m. Stalls were washed and cleaned twice every day, before the morning and afternoon feeding. Deworming and vaccinations were done as per farm schedule.

3 1.3. Feeding.

Rations were computed for individual animals as per the Sen et al. (1978) feeding standard. Ration for each animal consisted of a concentrate part and a roughage portion.

The concentrate part of the ration consisted of a commercially availa ble pelleted compound cattle feed conforming to ISI Standard IS 2052 (1968) The daily requirement of feed for each animal was calculated based on individual fortnightly recorded body weight The total monthly require ment of concentrate was estimated well in advance and the entire quantity was procured in a single lot and stored properly Representative sample from each lot was analysed for proximate composition and the data are presented in Table 1

Table 1

Chemical composition of concentrate fed to heifer calves
(percent on dry matter basis)

Fort nights	Dry matter	Crude pro- tein	Ether extract	Crude fibre	Total ash	Acid insolu- ble ash	Nitrogen free extract	Gross energy per kg(M cal)
1st	91 28	20 24	4 82	9 21	11 86	2 96	53 87	4 146
3rd	90 33	20 59	5 23	8 96	12 10	3 18	53 12	4 269
5th	91 12	21 02	4 97	7 92	12 21	3 42	53 88	4 200
7th	91 87	20 81	5 11	8 82	11 92	2 88	53 34	4 245
9th	90 66	20 25	4 78	7 82	12 62	3 26	54 53	4 168
11th	91 74	20 28	4 92	7 67	13 10	3 19	54 03	4 211
13th	91 94	20 61	4 88	7 27	12 29	2 99	54 95	4 220
15th	90.86	21 00	4 98	8.21	12 42	3 63	53 39	4 207
17th	91 37	20 82	5.00	8 14	12 67	3 21	53 37	4 316
19th	90 79	20 68	5 00	7 68	12 17	3 86	54 47	4 288
21st	91 33	20 79	4 79	8 79	11 86	2 98	53 77	4 217
23rd	91 00	20 17	5 11	8 21	11 79	3 63	54 72	4 300
25th	91 08	20 67	4 77	8 67	12 00	3 66	53 89	4 135
27th	91 00	20 11	4 62	8 12	11 98	3 58	55 17	4 125

The daily allowance of concentrate was fed in two equal lots, one each at 9 A.M. and 2 P.M. respectively on every day before feeding the fodder. The leftover feed, if any, was collected quantitatively and weighed to ascertain the actual daily intake of concentrate by each animal.

The roughage part of the ration consisted of green fodder in the form of Napier grass (*Pennisetum purpureum*, Linn). The green fodder harvested from the same area at the same stage of maturity was used for the feeding of both the groups of animals every day to minimise variation in composition. Representative samples of fodder used for the feeding of experimental animals were analysed once in every fortnight for proximate composition and the data are presented in Table 2.

The green fodder was fed in four divided lots at regular intervals on every day to ensure regularity and uniformity of feeding. The balance fodder left by each animal was collected and weighed separately every day to find out the quantity actually consumed by individual animals.

Salt lick (Surlex salt licks of M/s Chemical Salt Producers, Bhavnagar) was always made available to the animals. Water was provided *ad lib* and the data on daily intake of water by individual animals were maintained for 24 fortnights.

3.1.4. Proximate analysis of feeds and fodders.

The proximate analyses of feeds and fodders were carried out as per the standard methods described in A.O A C. (Anon., 1980).

Table 2
Chemical composition of roughage fed to heifer calves
(percent on dry matter basis)

Fort nights	Dry matter	Crude protein	Ether extract	Crude fibre	Total ash	Nitrogen free extract	Gross energy per kg (Mcal)
1.	19.05	8.53	2.10	27.00	7.72	54.65	4 064
2.	20.96	8.28	2.00	27.01	7.44	55.27	4.041
3.	20.66	8.35	2.10	27.40	7.62	54.53	4.073
4.	19.86	8.02	2.20	26.78	8.12	54.88	4.066
5.	19.33	8.46	1.99	26.40	7.45	55.70	3.980
6.	20.15	8.20	2.21	27.40	7.97	54.22	4.052
7.	20.36	8.58	1.96	27.90	7.65	53.91	3.936
8.	20.76	7.93	2.42	28.60	7.21	53.84	4.086
9.	22.32	7.84	1.88	28.00	8.00	54.28	3.983
10.	21.68	8.44	2.00	28.03	7.18	54.35	4.020
11.	21.17	7.55	2.01	27.40	7.63	55.41	4.035
12.	23.23	7.96	2.22	28.80	8.15	52.87	3.940
13.	25.37	8.13	1.88	29.80	8.05	52.14	4.088
14.	23.86	7.88	1.90	29.21	7.71	53.30	4.010
15.	23.56	8.17	1.86	28.90	7.59	53.48	3.962
16.	25.22	7.89	2.08	29.80	7.21	53.02	4.025
17.	22.76	8.14	2.21	27.70	7.68	54.27	4.011
18.	24.64	7.79	2.10	28.20	7.95	53.96	4.038
19.	25.35	7.83	1.89	29.80	7.32	53.16	3.978
20.	25.73	7.73	1.90	29.20	7.23	53.94	4.090
21.	25.37	7.63	1.80	29.00	7.42	54 15	3.964
22.	26.62	7.42	2.20	28.80	7.00	54.58	4.016
23.	25.52	7.74	2.00	29.70	7.16	53.40	4.000
24.	25.34	7.83	1.87	29.20	6.88	54.22	3.920
25.	24.85	8.04	1.90	28.80	7.28	53.98	4.036
26.	20.22	8.38	2.00	28.00	6.21	55.41	4.021
27.	19.76	8.25	2.10	28.40	6.15	55.10	4.066
28.	18.62	8.56	1.88	28.82	5.98	54 76	3 982

3.1.5. Weighing of animals.

Animals were weighed on the first day of each fortnight by means of an Avery Dorman self indicating platform weighing balance of two ton capacity, specially designed for the purpose with an accuracy of 200 g. Animals were weighed every time before 9 a.m. prior to feeding and watering.

3.1.6. Body measurements.

All body measurements were taken in metric system once in a month keeping the animals standing squarely on all four limbs and keeping the head in the normal position. Each measurement was taken twice and the average of the two readings was recorded.

Height measurements were made from the ground to the bottom of chest, top of withers and top of rump respectively using a Hauptner type of measureing rod.

Girth measurements were made at the regions of chest, paunch and flank by passing a metal tape around the trunk just behind the elbow joint, at the umbilicus and just in front of the stifle joint respectively.

Linear body measurements were recorded in terms of distance in a straight line between the pin bones, shoulder points, from point of shoulder to the pin bone and from the external angle of ileum to hip point using a metal tape.

3.1.7. Haematology

Blood samples for laboratory analysis were collected using reagent grade ethylenediaminetetraacetic acid disodium salt (EDTA) as anticoagulant at the rate of one mg per ml of blood. Blood samples were drawn from the jugular vein under aseptic conditions, for the determination of red cell, haemoglobin, plasma protein and enzyme concentrations once in a month.

Red cell counts were made using the improved Neubauer counting chamber with one in 200 dilution of blood with Hayem's solution as the diluting fluid (Coffin, 1953).

An acid haematin method (Cohen and smith, 1919) repeatedly checked against samples of blood, the haemoglobin content of which had been obtained by the Wong s method (Wong, 1928) was used for haemoglobin determination

Packed cell volume was determined using the method described by Wintrobe (1981).

Plasma protein was determined using the Biuret method of Gornall et al.(1949).

Estimations of Glutamic oxalacetic transaminase (GOT) and glutamic pyruvic transaminase (GPT) were carried out using the colorimetric method of Reitman and Frankel (1957)

3.1.8. Digestion-cum-balance trial.

Two digestion-cum-balance trials, one each during the 14th and 28th fort nights respectively were carried out for a period of seven days each. Before the commencement of the actual collection period in each digestion cum balance trial, the animals were subjected to a preliminary period of seven days when they were fed from the same consignment of concentrate and with the same type of fodder as that of the collection period and the animals were trained for facilitating easy collection of dung and urine quantitatively.

3.1 9. Sampling of feeds

Representative samples of both concentrate and roughage were taken every day during the trial for proximate analysis. The dry matter content of the feed was determined every day and the other components were estimated on a dry matter basis using composite samples taken after pooling the samples collected on all the seven days of the trial, as per standard methods described in A.O.A.C. (Anon., 1980).

3.1.10. Collection and sampling of dung.

Dung voided by each animal was collected manually in individual containers on a continuous 24 hour basis during the balance trial All possible precautions were taken to ensure the quantitative collection of dung uncontaminated by urine, feed residue or dirt. The entire quantity of dung voided by each animal during the previous 24 hours was weighed separately at 9 A.M. on every day and representative samples were taken after thorough mixing From the samples 1/100th aliquots of total dung were weighed out into metallic trays and were kept in hot air oven, for the dry matter determination of dung from each animal separately. Next day, the dried dung was weighed and was quantitatively removed to labelled air tight containers maintained separately for each animal. The process of collection, weighing, sampling and drying of dung was continued till the end of the trials. Thus a 1/100 representative sample of the total dung voided was collected and dried and was preserved in respective labelled containers in the powder form for further analysis. For the estimation of nitrogen, 1/1000 aliquot of the total dung was taken daily and was preserved in 25% H_2SO_4 in glass stoppered, wide mouthed, labelled bottles, the weights of which had been determined previously. Such samples were preserved from the dung voided on all the seven days of the trial. Another one percent aliquots of total dung voided by each animal on all the seven days of the trial were stored in air-tight polythene (polyvinyl) bags in a frozen state. Composite samples taken after thorough mixing of the pooled aliquots collected on all the seven days of the trial were used for the determination of various proximate principles as per the standard methods described in A.O.A.C. (Anon., 1980).

3.1.11. Collection and sampling of urine.

Urine from each animal was collected manually in individual containers on a continuous 24 hour basis during the balance trial, taking all possible precautions to ensure quantitative collection without being contaminated with dung or dirt. The entire quantity of urine collected from each animal during the previous 24 hours was measured separately at 9 A.M. on every day and one per cent duplicate aliquots of the total urine were measured into separate labelled containers for each animal. One sample was preserved with 10 per cent thymol and the other with 25 per cent sulphuric acid. Composite samples taken from the pooled aliquots were used for the estimation of nitrogen at the end of the balance trial as per the standard methods described in A.O.A.C. (Anon., 1980).

3.1.12. Estimation of gross energy.

The gross energy values of samples of feed and dung collected during the experimental period were estimated using a parr oxygen adiabatic bomb calorimeter following the method prescribed by the manufacturer.

3.1.13. Efficiency of feed utilization.

Efficiency of utilization of dry matter, gross energy, total digestible nutrients, digestible energy, crude protein and digestible crude protein of the ration was calculated.

3.1.14. Statistical analysis.

The data were analysed as per standard methods of statistical analyses viz. t-test, analysis of variance - CRD and analysis of co variance as described by Snedecor and Cochran (1968).

Part II

3 2. Lactation study

Two groups of six lactating cows each, belonging to the two genetic groups of crossbred Jersey and crossbred Brown Swiss, were arranged in a completely randomised design and were maintained under identical conditions of housing, feeding and management, for a total period of 13 fortnights. Individual records of daily intake of concentrate and roughage, daily milk yield and fortnightly body weights were maintained. Haematological values of animals were assessed once in two fortnights. A digestion-cum-balance trial was carried out during the 11th fortnight.

3.2.1. Animals.

Healthy milch cows belonging to the two genetic groups of half bred Jersey (Group I) and half bred Brown Swiss (Group II) formed the experimental subjects. The animals were obtained from the University Livestock Farms at Thiruvazhamkunnu and Mannuthy. They were comparatively higher milk yielders and all of them had attained their peak yield. Animals were selected in such a way that the two groups were essentially similar in respect of age, body weight, number and stage of lactation and daily milk yield.

3.2.2.Housing and management.

All the milch cows were housed in a single shed constructed in a north south direction Animals were tied in two rows in a tail to tail pattern.

Each animal was provided with individual mangers having masonry walls on either side to prevent each animal from getting at the feed of the adja cent animal. Stall feeding was practised throughout the experimental period Animals were washed every day in the morning before 9 A.M. Stalls were clean ed twice every day before the morning and afternoon milking with frequent removal of dung. All vaccinations were done as per the farm routine.

3.2.3. Feeding.

Rations were computed for individual animals as per the Sen et al. (1978) feeding standard. Ration for each animal consisted of a concentrate part and a roughage part.

The concentrate part of the ration consisted of a commercially available pelleted compounded cattle feed conforming to I.S.I. Standard IS 2052, as described under Part I. The daily requirement of feed for each cow was calculated based on individual body weight and the average quantity of milk produced at the beginning of each fortnight. The total monthly requirement of concentrate for the two groups of animals was estimated well in advance and the entire quantity was purchased in a single lot and stored properly. Representative samples of each lot was analysed for proximate composition and the data are presented in Table 3.

The daily allowance of concentrate was fed in full in two lots just prior to the morning and afternoon milking at 3 A.M. and 4 P.M. respectively every day and the left over portions, if any, were collected and weighed to find out the actual daily consumption of concentrate by individual animals.

Table 3
Chemical composition of concentrate fed to cows
(percent on dry matter basis)

Fort nights	Dry matter	Crude protein	Ether extract	Crude fibre	Total ash	Acid insoluble ash	Nitrogen free extract	Gross energy per kg (M cal)
1st	92.69	19.14	3.37	8.41	12.68	2 88	56.40	4.1426
3rd	90 43	21.90	4.87	5.73	12.16	3.32	55.34	4.2119
5th	90.50	20.27	4.25	8.86	11.82	2 74	54.80	4.1238
7th	90 80	20.72	4.67	9.22	12.23	3.63	53.16	4.2239
9th	90.70	20.14	4.99	8.88	11.00	3.18	54.99	4.2450
11th	91.50	20.70	4.16	5.58	11.00	3.27	58.56	4.1089
13th	91.00	20.51	4.78	8.83	12.22	3.58	53.66	4.2319

The roughage part of the ration consisted of green fodder in the form of Napier grass (Pennisetum purpureum, Linn.). The green fodder harvested from the same area at the same stage of maturity was used for the feeding of animals in both the groups to minimise variation in composition. Representative samples of fodder used for feeding were analysed once in every fortnight for proximate composition and the data are presented in Table 4

The green fodder was fed in four divided lots every day to ensure minimu wastage, regularity and uniformity of feeding. Feeding of green fodder in the afternoon was always done after feeding the concentrate part of the ration. The balance fodder,left over by each animal was collected and weighed separately every day to find out the quantities actually consumed by individual animals.

Table 4
Chemical composition of roughage fed to cows
(percent on dry matter basis)

Fort-nights	Dry matter	Crude protein	Ether extract	Crude fibre	Total ash	Nitrogen free extract	Gross energy per kg (M cal)
1st	20.01	8.59	2.26	26.38	7.18	55.59	4.0866
2nd	20.03	8.13	2.27	26.06	6.79	56.75	4.1020
3rd	21.17	7.62	2.34	26.88	7.77	55.39	4.1108
4th	22.84	8.33	2.11	26.14	8.32	55.10	4.0283
5th	23.33	7.86	2.28	27.73	7.96	54.17	4.0962
6th	26.19	7.64	1.99	28.56	8.34	53.47	4.1280
7th	25.55	7.85	1.87	27.62	8.11	54.55	4.1121
8th	26.74	7.53	2.21	28.37	7.98	53.91	4.0290
9th	25.61	7.78	1.95	28.60	7.75	53.92	4.0927
10th	25.91	7.55	2.00	27.84	8.28	54.33	4.1690
11th	26.09	7.98	2.12	27.66	8.97	53.27	4.1100
12th	26.75	7.44	2.10	28.94	7.99	53.53	4.0909
13th	24.22	7.89	1.87	27.72	7.18	55.34	4.1720

Salt lick (Surlex salt licks of M/s Chemical Salt producers, Bhavnagar) was always made available to the animals. Water was provided ad lib.

3.2.4. Milking and milk recording.

Animals were milked 3 times a day viz. 3 A.M., 10 A.M. and 4P.M. respectively according to the farm routine, the timings being strictly adhered to during the entire period of experiment. Hand milking was practised for all the cows throughout the experimental period. The same milker was always engaged for milking both the groups of cows. The total quantity of milk obtained from each cow at each milking was weighed accurately using a herd recorder having an accuracy of 50 g.

3.2.5. Proximate analysis of feeds and fodders.

The proximate analyses of feeds and fodders were carried out as per the standard methods described in A.O.A.C. (Anon., 1980).

3.2.6. Weighing of animals.

All animals were weighed at fortnightly intervals as described under Part I.

3.2.7. Collection and analysis of blood.

Blood samples from all the experimental animals were collected once in a fortnight as per the procedure described under Part I and were analysed for RBC, haemoglobin, P.C.V., plasma protein, GOT and GPT concentrations using the methods mentioned under Part I.

3.2.8. Digestion cum-balance trial.

A digestion-cum-balance trial was carried out during the 11th fortnight as per the procedure described under Part I.

Samples of feed, dung and urine taken as described under Part I were analysed by using standard procedures described in A.O.A.C (Anon., 1980).

3.2.9. Sampling of milk.

Milk samples were taken from every animal at each milking on all seven days of balance trial and at fortnightly intervals during the rest of the experimental period. Composite samples were prepared by mixing proportionate quantities (5%) of milk from each of the three milkings of every cow. The samples were stored in chilled condition for analysis.

3.2.10. Analysis of milk samples.

Milk samples were mixed thoroughly before analysis. Milk protein was estimated by using the procedure described in Indian Standards IS: 1479, Part II (1961). Milk fat was determined by using the Gerber's method as described in Indian Standards, I.S: 1224 (1958). The gravimetric method described in Indian Standards, I.S: 1479 Part II (1961) was employed for the estimation of total solids content of milk. The solids-not-fat content of milk was calculated by subtracting the fat percentage from the total solids percentage.

3.2.11. Fat corrected milk (FCM).

The fat corrected milk was calculated by using Gaines formula (Gaines,1928).

Four per cent fat corrected milk (kg) - 0.4 M + 15 F

where

M   weight of milk (kg)

F - weight of fat contained in it (kg)

3.2.12. Solids corrected milk (SCM).

The solids-corrected milk was arrived at by using the formula of Tyrell and Reid (1965):

SCM (kg) - 12.3 (F) + 6.56 (SNF) - 0.0752 (M)

where

SCM - solids-corrected milk (kg)

F   fat (kg)

SNF - solids-not-fat (kg)

M = milk (kg)

3.2.13. Efficiency of feed utilisation.

Efficiency of utilisation of dry matter, gross energy, total digestible nutrients, digestible energy, crude protein and digestible crude protein of the ration was calculated.

3.2.14. Economic efficiency.

Economic efficiency of milk production was calculated in terms of income over feed cost (IOFC) and dairy merit.

Income over feed cost was calculated as per method described by Jadhav and Bhatnagar (1986):

IOFC (Rs) (Milk yield x milk price) - feed cost.

The prevailing market rates (1988 89) of Rs 5.00, Rs 2.40 and Rs 0 25 respectively per kg of milk, concentrate and cultivated fodder were used for calculation of IOFC.

Dairy merit was calculated by using the formula suggested by Brody (1968):

$$\text{Dairy merit} = \frac{\text{milk energy production}}{\text{TDN energy consumption}} \times 100$$

Calorific value of TDN was taken as 4.4 kcal/g as suggested by Maynard *et al*. (1979) instead of 4 kcal/g suggested by Brody (1968).

3.2.15. Statistical analysis.

The data were analysed as per standard methods of statistical analysis, viz. t-test, analysis of variance - C.R.D. and analysis of co-variance as explained by Snedecor and Cochran (1968).

RESULTS

4. RESULTS

The results obtained during the growth and lactation studies are presented separately under Part I and Part II respectively.

The summarised data and the statistical analyses of results obtained in respect of body weight, weight gain, body measurements, food intake, water intake, haematological values, digestion coefficients of nutrients and efficiency of utilisation of dry matter, gross energy, total digestible nutrients, digestible energy, crude protein, digestible crude protein and nitrogen for growth in crossbred Jersey and crossbred Brown Swiss heifer calves are presented in tables 5-50 and figures 1-10 under Part I and those obtained in respect of body weight, weight gain, food intake, concentrate roughage ratio, digestion coefficients of nutrients, haematological values, milk yield, composition of milk and efficiency of utilisation of dry matter, gross energy, total digestible nutrients, digestible energy, crude protein, digestible crude protein and nitrogen as well as economic efficiency of milk production in crossbred Jersey and crossbred Brown Swiss cows in tables 51 to 114 and figures 11 - 22 under Part II respectively.

Part I
GROWTH STUDY

Table 5
Summarised data on average fortnightly body weight (kg)

Fortnights	Fortnightly body weight (kg $\pm$ SE) Group A	Group B
Initial	64.75±6.61	74.19±6.46
1	70.75±6.88	79.44±6.97
2	76.63±7.25	84.69±7 14
3	81.63±7.11	89.88±7.24
4	86.65±7.27	95.18±7.27
5	91.75±7.33	100.38±7.52
6	96.63±7.28	105.88±8.00
7	101.25±7.40	110.25±8.42
8	106.28±7.41	115.20±8.13
9	112.63±7.29	120.00±8.01
10	117.25±7.39	124.81±8.05
11	122.00±7.40	129.38±8.19
12	127.63±7.45	134.25±8.28
13	132.00±7.40	138.44±8.14
14	137.00±7.51	142.31±8.47
15	141.88±7.43	147.13±8.86
16	145.88±7 42	151.81±8.75
17	150.63±7.44	156.50±9.22
18	155.13±7.93	160.50±9.46
19	159 69±8.36	164.50±9.73
20	163.75±8.78	168.56±9.86
21	168.94±9 00	173.44±10.35
22	175.06±8.64	178.56±10.17
23	180.13±8.57	183.00±9.94
24	185.13±8.88	188.13±10.20
25	190.38±9.17	192.50±10.50
26	194.75±9.36	196.56±10.83
27	200.38±9.13	200.50±11.11
28	204.50±9.10	203.75±11.40

Table 6

Statistical analysis of fortnightly data on body weight

A N O C O V A (Ist fortnight)

SOURCE	DF	SXX	SXY	SYY
Treatment	1	356.27	327.95	301.89
Error	14	4783.97	5062.84	5372.22
Total	15	5140.23	5390.80	5674 11
		Unadjusted Treatment + Error		
Treatment+Error	15	5140.23	5390.80	5674.11

Estimate of Reg.Coefficient (b cap) - 1.0583
Adj. Error - 14.2437 with 13 df
Adj. (Treat.+Error) 20.5366 with 14 df
Adjusted Treat. - 6.2930 with 1 df
F - 5.7435* with 1 and 13 df.

Table 7

Statistical analysis of fortnightly data on body weight

A N O C O V A (14th fortnight)

SOURCE	DF	SXX	SXY	SYY
Treatment	1	356.27	200.55	112.88
Error	14	4783.97	5396.03	7179.47
Total	15	5140.23	5596.58	7292.34
		Unadjusted Treatment + Error		
Treatment + Error	15	5140.23	5596.58	7292.34

Estimate of Reg. Coefficient (b cap) - 1.1279
Ad. Error 1093.0674 with 13 df
Adj. (Trea. + Error) - 1198.9083 with 14 df
Adjusted Treat. - 105.8408 with 1 df
F - 1.2588 with 1 and 13 df (NS)

* Significant at 5% level
NS - Not significant

Table 8
Statistical analysis of fortnightly data on body weight
A N O C O V A (28th fortnight)

SOURCE	DF	SXX	SXY	SYY
Treatment	1	356.27	-28.31	2.25
Error	14	4783 97	5659.87	11917 50
Total	15	5140 23	5631.56	11919 75
	Unadjusted Treatment + Error			
Treatment+Error	15	5140.23	5631.56	11919 75

Estimate of Reg.Coefficient (b cap) - 1.1831
Adj. Error 5221.3468 with 13 df
Adj. (Treat. + Error) = 5749.8960 with 14 df
Adjusted Treat. 528.5489 with 1 df
F - 1.3160 with 1 and 13 df (NS)

Table 9

Summarised data on average fortnightly weight gain

Group A			Group B			t value A vs B
Animal number	Av.fortnightly weight gain (kg±SE)	Av.daily weight gain (g)	Animal number	Av.fortnightly weight gain (kg±SE)	Av. daily weight gain (g)	
1.	5.32±0.32	380.0	9	5.07±0.27	362.1	
2.	4.09±0.25	292.1	10	3.93±0.31	280.7	
3 .	4.95±0.31	353.6	11	4.64±0.27	331.1	
4.	4.36±0.31	311.4	12	6.04±0.24	431.4	
5.	5.07±0.28	362.1	13	5.04±0.29	360.0	
6.	5.54±0.27	395.7	14	4.21±0.24	300.7	
7	4.57±0.33	326.4	15	3.66±0.21	261.4	
8.	6.04±0.23	ι 31.4	16	4.36±0.26	311.4	
Mean ±SE	4 99 ±0.23	356.59 ±16.27		4 62 ±0.27	329.85 ±19.16	1.034 NS

NS Not significant

Table 10

Summarised data on average monthly height measurements

Month	Average height at the bottom of chest (cm±SE) Group A	Group B	Average height at wither (cm±SE) Group A	Group B	Average height at rump (cm±SE) Group A	Group B
1.	48.00±0.46	48.50±0.91	90.50±1.46	91.50±2 04	94.13±1.60	94.63±1.79
2.	48.50±0.46	49.00±0.91	91.75±1.44	92.63±2.04	95.38±1.51	96.00±1.89
3.	48.94±0.45	49.25±0.97	93.38±1.36	94.00±2.11	96.63±1.45	97.38±1.93
4.	49.38±0.41	49.75±0.97	94.88±1.19	95.50±2.07	98.00±1.36	98.63±1.96
5.	49.88±0.41	50.25±0.97	96.38±1.05	97 00±2.07	99.63±1.32	100.38±1.93
6.	50.25±0.43	50.69±0.99	97.88±0.93	98.25±2.07	101.25±1.36	101.75±1.98
7	50.75±0.43	51.13±0.99	99.38±0.87	99.75±2.01	102.63±1.32	103.13±1.93
8.	51.19±0.47	51.44±1.05	101.13±0.81	101.00±1.93	104.25±1.28	104.88±1.99
9.	51.88±0.49	51.94±1.05	103.13±0.85	102.75±1.91	105.75±1.21	106.50±1.98
10.	52.19±0.54	52.31±1.08	104.75±0.88	104.13±1.83	107.63±1.10	108.13±1.98
11.	52.81±0.57	52.75±1.06	106.38±0.82	105.25±1.89	108.81±1.04	109.25±2.01
12.	53.00±0.69	53.00±1.07	107.63±0.87	106.19±1.88	110.13±1.03	110.25±2.08
13.	53.50±0.77	53.31±1.09	108.75±0.95	107.06±1.94	111.19±0.90	111.06±2.10
14.	53.81±0.91	53.50±1.04	109.63±0.96	108.06±1.91	112.13±0.92	111.75±2.07

Table 11

Statistical analysis of monthly data on height at the bottom of chest

A N O C O V A (last month)

SOURCE	DF	SXX	SXY	SYY
Treatments	1	1.00	63	.39
Error	14	58.00	67.00	105.97
Total	15	59.00	66.38	106.36
Unadjusted Treatment + Error				
Treatment+Error	15	59.00	66.38	106 36

Estimate of Reg Coefficient (b cap) - 1.1552
Adj.Error - 28.5722 with 13 df
Adj.(Treat.+Error) - 31.6875 with 14 df
Adjusted Treat - 3.1153 with 1 df
F 1.4174 with 1 and 13 df (NS)
NS - Not significant

Table 12
Statistical analysis of monthly data on height at wither

A N O C O V A (last month)

SOURCE	DF	SXX	SXY	SYY
Treatments	1	4.00	6.25	9.77
Error	14	354.00	184.75	255.09
Total	15	358.00	178.50	264.86
	Unadjusted Treatment + Error			
Treatment + Error	15	358.00	178.50	264 86

Estimate of Reg.Coefficient (b cap) - .5219
Adj. Error - 158.6741 with 13 df
Adj. (Treat. + Error) - 175.8587 with 14 df
Adjusted Treat. = 17.1846 with 1 df
F = 1.4079 with 1 and 13 df (NS)

Table 13
Statistical analysis of monthly data on height at rump

A N O C O V A (last month)

SOURCE	DF	SXX	SXY	SYY
Treatments	1	1.00	-.75	56
Error	14	322.75	233.13	286.38
Total	15	323 75	232.38	286 94
	Unadjusted Treatment + Error			
Treatment + Error	15	323.75	232.38	286 94

Estimate of Reg.Coefficient (b cap) - .7223
Adj.Error - 117.9869 with 13 df
Adj.(Treat. + Error) - 120.1479 with 14 df
Adjusted Treat. = 2.1610 with 1 df
F = .2381 with 1 and 13 df (NS)
NS - Not significant

Table 14
Summarised data on average monthly girth measurements

Months	Average chest girth (cm+SE) Group A	Group B	Average paunch girth (cm+SE) Group A	Group B	Average flank girth (cm+SE) Group A	Group B
1.	99.50+3.81	101.38+2.98	131.50+3.78	128.50+3.60	103.88+3.22	105.50+3.35
2.	103.50+3.54	105.25+2.74	134 38+3.79	131.00+3.52	106.75+3.10	108.63+3.30
3.	107.00+3.33	108.88+2.47	136.88+3.65	133.50+3.51	109.50+3.11	111.63+3.28
4.	110.38+3.09	111.50+2.58	139.13+3.59	136.06+3.44	112.25+3.01	114.38+3.18
5.	114.13+2.77	115.00+2.49	141.31+3.47	138.69+3.44	115.50+2.90	117 88+3.29
6.	117.56+2.66	118.50+2.23	143.63+3.47	141.25+3.34	118.38+2.79	121.63+3.21
7.	121.25+2.54	121 50+2.32	146.13+3.27	143.75+3.30	121.88+2.54	124.75+3.17
8.	125.25+2.27	124.88+2.26	148.63+3.09	145.63+3.45	125.38+2.45	127.38+3.16
9.	128.38+2.16	128.50+2.08	151.13+3.07	148.00+3.53	128.88+2.26	129 88+3.04
10.	131.25+1.93	131.38+1.98	153.81+2.86	150.38+3.52	132.13+2.26	132.63+3.07
11	134.38+1.92	133.50+2 14	156.25+2.74	152.38+3.69	135.38+2.28	135 88+3.32
12	136.88+1.86	135.38+2.12	159.00+2.52	154.63+3.72	138.50+2.34	139.'3+3.36
13.	138.63+1.86	136.63+2.20	161.00+2.29	156.88+3.71	141.25+2.48	141.88+3.37
14.	140.19+1.97	138.06+2.25	163.63+2.20	158.69+3.59	144.13+2.64	144.25+3.52

Table 15
Statistical analysis of monthly data on chest girth
A N O C O V A (last month)

SOURCE	DF	SXX	SXY	SYY
Treatments	1	14 06	15.94	18.06
Error	14	1309 88	628.56	501 19
Total	15	1323.94	612.63	519 25
	Unadjusted Treatment + Error			
Treatment+Error	15	1323.94	612.63	519 25

Estimate of Reg.Coefficient (b cap) 4799
Adj.Error - 199.5627 with 13 df
Adj. (Treat. + Error) - 235.7703 with 14 df
Adjusted Treat. - 36.2076 with 1 df
F = 2.3587 with 1 and 13 df (NS)

NS - Not significant

Table 16
Statistical analysis of monthly data on paunch girth
A N O C O V A (last month)

SOURCE	DF	SXX	SXY	SYY
Treatments	1	36.00	59.25	97.50
Error	14	1524.00	1015.25	991 34
Total	15	1560.00	1074 50	1088 84
	Unadjusted Treatment + Error			
Treatment + Error	15	1560.00	1074 50	1088 84

Estimate of Reg.Coefficient (b cap) 6662
Adj. Error - 315.0101 with 13 df
Adj. (Treat + Error) - 348 7474 with 14 df
Adjusted Treat. 33.7374 with 1 df
F - 1 3923 with 1 and 13 df (NS)

NS Not significant

Table 17
Statistical analysis of monthly data on flank girth
A N O C O V A (last month)

SOURCE	DF	SXX	SXY	SYY
Treatments	1	10.56	.81	06
Error	14	1208.87	954 13	1086.38
Total	15	1219.44	954.94	1086 44
	unadjusted Treatment + Error			
Treatment + Error	15	1219 44	954.94	1086.44

Estimate of Reg.Coefficient (b cap) - 7893
Adj.Error 333.3158 with 13 df
Adj. (Treatment+Error) - 338.6291 with 14 df
F 2072 with 1 and 13 df (NS)
NS Not significant

Table 18
Summarised data on average monthly length measurements

Months	Average body length (Cm±SE) Group A	Group B	Average distance between shoulder points (cm±SE) Group A	Group B	Average distance between pin bones (cm±SE) Group A	Group B	Average distance from external angle of ileum to hip points(cm±SE) GroupA	Group B	Average distance between hip points(cm±SE) Group A	Group B
1	77.88±2 50	79 63±2 06	25 38±0.68	24.50±0 89	8.25±0 35	8.44±0 32	19 06±0 18	18 75±0.31	36 13±1.09	36.50±1.51
2	79 50±2.53	81 25±2.11	26 50±0 68	25 75±0 96	8 31±0.39	8 63±0 34	19 38±0.13	18 94±0.31	37.06±1.08	37.50±1.51
3.	81 25±2 40	83 00±2 22	27.75±0.65	26 75±0.96	8.69±0.39	9.00±0 38	19 69±0 13	19.31±0 33	38 13±1.06	38.50±1.51
4.	83.50±2 20	85.25±2 11	28 88±0 58	28 13±0 88	8 88±0.42	9 19±0 37	20 13±0 16	19 44±0.31	39.25±1 00	39 88±1 46
5.	85.88±2 10	87.69±2.14	29 81±0.58	29.38±0.91	8 88±0.42	9.25±0.39	20 56±0 18	19.94±0.31	40.50±1.10	41.13±1.34
6	87.88±1 86	89.88±2 05	30 88±0.58	30.50±0 96	9 38±0.42	9 63±0 43	20 94±0 24	20 25±0 33	41 88±1.04	42 38±1.38
7	89 75±1 75	92 25±2 00	32 13±0.58	32 00±0 91	9 38±0 42	9 81±0 42	21 44±0 24	20 81±0 25	43 25±1 00	43.88±1 42
8.	91 69±1 65	94 25±1.96	33 06±0 59	33.25±1 00	9.56±0.42	9.94±0 47	21 88±0 26	21 31±0 30	44.88±0.88	45.38±1 44
9	93 50±1 64	96 00±1 97	34.13±0 69	34.25±1 00	9 88±0.42	10 25±0 50	22.31±0.28	21 81±0.38	45.88±0.88	46 56±1 53
10.	95 38±1 68	97 63±1 92	35 25±0.70	35 50±1 04	10 00±0 38	10 56±0 51	22 75±0 25	22 13±0 39	47 31±0 79	47.88±1 70
11.	97.38±1 72	99 00±1.98	36.50±0.78	36 50±1.04	10 13±0.40	10.81±0.53	23.00±0.27	22.56±0 42	48.63±0 80	48.94±1 71
12	99 25±1.72	100.38±2 01	37.38±0 84	37.44±1.04	10 50±0 38	11.19±0.55	23 44±0.29	23 06±0 42	49.75±0 84	50 00±1 73
13.	100.75±1.63	101.69±2 19	38 25±0.92	38.13±1 07	10.69±0.39	11.50±0.58	23.81±0 23	23.38±0.38	50.81±0.83	50.81±1.79
14.	102 63±1.56	102 75±2 21	39 13±0 99	38 75±1.05	10 88±0.38	11.75±0.56	24.13±0 30	23.75±0.41	51.63±0 80	51.38±1.90

Table 19
Statistical analysis of monthly data on body length

A N O V A T A B L E (last month)

SOURCE	DF	SS	MSS	F
Treatment	1	.063	.063	.002 NS
Error	14	409.375	29.241	
Total	15	409.437		

SE of the difference between treatment 1 and 2 = 2 70375

CD at 5% level - 5.79955.

CD at 1% level - 8.04907

Table 20
Statistical analysis of monthly data on distance between shoulder points

A N O C O V A (last month)

SOURCE	DF	SXX	SXY	SYY
Treatments	1	3.06	1.31	.56
Error	14	69.88	78.62	116.37
Total	15	72.94	79.94	116.94
Unadjusted Treatment + Error				
Treatment + Error	15	72.94	79 94	116.94

Estimate of Reg. Coefficient (b cap) 1.1252
Adj. Error - 27.9043 with 13 df
Adj. (Treat. + Error) - 29 3282 with 14 df
Adjusted Treat. - 1.4239 with 1 df
F - .6634 with 1 and 13 df (NS)
NS - Not significant

Table 21

Statistical analysis of monthly data on distance between pin bones

A N O C O V A (last month)

SOURCE	DF	SXX	SXY	SYY
Treatments	1	.14	66	3 06
Error	14	12.72	13.88	25.38
Total	15	12.86	14.53	28.44
	Unadjusted Treatment + Error			
Treatment + Error	15	12.86	14.53	28.44

Estimate of Reg. Coefficient (b cap) - 1.0909
Adj.Error - 10.2386 with 13 df
Adj. (Treat. + Error) - 12.0170 with 14 df
Adjusted Treat. 1.7784 with 1 df
F - 2.2580 with 1 and 13 df (NS)

Table 22

Statistical analysis of monthly data on distance from external angle of ileum to hip point

A N O C O V A (last month)

SOURCE	DF	SXX	SXY	SYY
Treatments	1	.39	.47	56
Error	14	7 22	7.44	14.37
Total	15	7 61	7.91	14.94
	Unadjusted Treatment + Error			
Treatment + Error	15	7.61	7.91	14.94

Estimate of Reg.Coefficient (b cap) - 1.0303
Adj.Error - 6.7121 with 13 df
Adj. (Treat. + Error) - 6 7228 with 14 df
Adjusted Treat. - 0107 with 1 df
F .0207 with 1 and 13 df (NS)

NS - Not significant

Table 23
Statistical analysis of monthly data on distance between hip points
A N O C O V A (last month)

SOURCE	DF	SXX	SXY	SYY
Treatments	1	.56	-.37	25
Error	14	194 87	174.88	237.75
Total	15	195.44	174.50	238.00
	Unadjusted Treatment + Error			
Treatment + Error	15	195.44	174.50	238.00

Estimate of Reg.Coefficient (b cap) - .8974
Adj.Error - 80.8224 with 13 df
Adj. (Treat. + Error) - 82.1944 with 14 df
Adjusted Treat. - 1.3720 with 1 df
F -.2207 with 1 and 13 df (NS)

Table 24
Summarised data on average fortnightly DM consumption (kg)

Animal number	Group A Average fortnightly DM consumption (kg±SE)	Animal number	Group B Average fortnightly DM consumption (kg±SE)	t values A vs B
1.	72.98±1.89	9.	70.47±1 50	
2.	53.80±1.66	10.	68.41±1.82	
3.	62.80±2.32	11.	62.06±1.55	
4.	54.70±1.90	12.	64.36±2 09	
5.	57.97±1.94	13.	54.45±1.70	
6	58.00±2.40	14.	53.06±1.66	
7.	49.92±1.90	15.	53.90±1.98	
8.	55.17±2.72	16.	50.78±2.13	
Mean±SE	58.17±2.50		59.69±2.69	0.611 NS

NS - Not significant

Table 25
Summarised data on average daily DM consumption (kg) per 100 kg body weight

Group A		Group B		
Animal number	Average daily DM intake kg/100 kg body weight ±SE	Animal number	Average daily DM intake kg/100 kg body weight ±SE	t value A vs B
1.	2.94±0.06	9.	2.93±0.08	
2.	3.22±0.08	10.	3.34±0.07	
3.	3.28±0.08	11.	3.07±0.09	
4.	3.28±0.07	12.	3.02±0.09	
5.	3.37±0.11	13.	3.90±0.09	
6.	3.33±0.11	14.	3.23±0.09	
7.	3.30±0.09	15.	3.64±0.07	
8.	3.33±0.11	16.	3.49±0.09	
Mean±SE	3.26±0.05		3.33±0.12	0.58 NS

NS - Not significant

Table 26
Summarised data on fortnightly consumption of water

Animal number	Group A Average fortnightly water intake (kg±SE)	Animal number	Group B Average fortnightly water intake (kg±SE)	t-value A vs B
1.	233.08±13.14	9.	187.14±9.36	
2.	186.35±8.58	10.	182.24±5.98	
3.	193.25±10.62	11.	296.20±11.25	
4.	219.53±15.22	12.	238.23±39.42	
5.	181.23±11.61	13.	172.51±7.88	
6.	172.24±12.28	14.	166.06±7.55	
7.	285.46±12.14	15.	146.27±8.29	
8.	188.51±9.10	16.	168.46±8.10	
Mean±SE	207.46±13.24		194 64±17.30	0.539 NS

Table 27
Summarised data on haematological values -
Red cell and haemoglobin concentration

Red blood cell					Haemoglobin				
Group A		Group B		t value	Group A		Group B		t value
Animal number	Million per mm^3	Animal number	Million per mm^3	A vs B	Animal number	g per 100 ml	Animal number	g per 100 ml	A vs B
1.	8.71±0.20	9.	9.56±0.29		1.	10.24±0.19	9	11.13±0.20	
2.	8.96±0.17	10.	8.85±0.11		2.	10.35±0.17	10	10.29±0.13	
3.	9.99±0.23	11.	9.21±0.24		3.	11.29±0.19	11.	10.86±0.23	
4.	8.89±0.29	12.	9.09±0.18		4.	10.36±0.24	12.	10.36±0.18	
5.	9.33±0.21	13.	8.97±0.24		5	10.68±0.21	13.	10.52±0.19	
6.	8.59±0.23	14.	9.19±0.21		6.	10.30±0.19	14.	10.72±0.19	
7	8.87±0.30	15.	8.40±0.20		7.	10.32±0.22	15.	9.80±0.20	
8.	8.94±0.17	16.	8.76±0.21		8.	10.39±0.22	16.	10.36±0.19	
Mean± SE	9.04±0.16		9.00±0.12	0.074 NS		10.49±0.12		10.51±0.14	0.100 (NS)

NS Not significant

Table 28

Summarised data on haematological values - Packed cell volume and plasma protein concentration

Packed cell volume					Plasma protein				
Group A		Group B		t value A vs B	Group A		Group B		t value A vs B
Animal number	Percent	Animal number	Percent		Animal number	g/100 ml	Animal number	g/100 ml	
1.	32.36±0.37	9	30.71±0.42		1.	6.30±0.12	9.	6.15±0.07	
2.	36.79±0.32	10.	32.86±0.67		2.	6.42±0.12	10.	6.20±0.12	
3.	35.07±0.22	11.	30.43±0.36		3.	6.29±0.13	11.	6.49±0.10	
4.	34.07±0.74	12.	35.50±0.31		4.	6.22±0.09	12.	6.29±0.14	
5.	28.57±0.17	13.	36.93±0.32		5.	6.17±0.13	13.	6.23±0.13	
6.	36 14±0.35	14.	27.93±0.30		6.	6.38±0.12	14.	6.11±0 11	
7.	34.71±0.40	15.	37.14±0.25		7.	6.08±0.10	15.	6.25±0 16	
8.	30.79±0.43	16.	33.50±0.29		8.	6.16±0.10	16.	6.34=0.11	
Mean ±SE	33.56±0.99		33.13±1.17	0.237 NS		6.25±0.04		6.26±0.04	0.040 (NS)

Table 29

Summarised data on haematological values - Serum glutamic oxalo acetic transaminase and glutamic pyruvic transaminase concentration

Glutamic oxalo acetic transaminase					Glutamic pyruvic transaminase				
Group A		Group B		t value A vs B	Group A		Group B		t value A vs B
Animal number	Units/ ml serum± SE	Animal number	Units/ml serum ±SE		Animal number	Units/ ml serum± SE	Animal number	Units/ml serum± SE	
1.	39.57±1.37	9.	40.00±1.84		1.	13 07±0.46	9.	13.29±0.35	
2	43.07±1.16	10.	40.86±2.13		2.	12.64±0.59	10.	12.14±0.59	
3.	41.57±1.70	11.	43.79±2.04		3.	12.64±0.52	11.	12.79±0.53	
4.	40.93±1.88	12.	39.64±1.29		4.	13.00±0.59	12.	12.79±0.74	
5.	42.57±1.49	13.	43.57±1.80		5.	13.00±0.82	13.	12.21±0.70	
6.	40.57±0.89	14.	39.79±1.13		6.	12.07±0.65	14.	12.57±0.51	
7.	37.86±1.94	15.	41.79±1.65		7.	11.07±0.64	15.	11.50±0.61	
8.	38.64±2.50	16.	39.36±2.27		8.	11.21±0.62	16.	11.57±0.74	
Mean ±SE	40.60±0.65		41.10±0 63	0.717 NS		12.34±0.28		12.36±0.22	0.108 (NS)

NS - Not significant

Table 30
Summarised data on digestion trial I

	Group A	Group B	t values A vs B
Number of animals	8	8	
Average body weight (kg)	137.0±7.51	142.31±8.47	
Average digestibility coefficient of DM %	59.40±0.59	59.55±1.60	0 106 NS
Average digestibility coefficient of curde protein %	61.29±0.78	61.35±0.72	0 067 NS
Average digestibility coefficient of crude fat %	66.81±2.06	66.32±1.49	0.245 NS
Average digestibility coefficient of crude fibre %	55.68±1.28	62 27±1.12	6.949 *
Average digestibility coefficient of nitrogen free extract %	66.84±0.48	65.26±1.76	0.875 NS
Average digestibility coefficient of gross energy %	65.70±0.64	66.46±1.45	0.558 NS

Table 31
Summarised data on digestion trial II

	GroupA	Group B	t values A vs B
Number of animals	8	8	
Average body weight (kg)	204.50±9.1	203.75±11.4	
Average digestbility coefficient of DM %	58.99±1.02	60.01±0.9	0.609 NS
Average digestibility coefficient of crude protein %	59 91±0.82	60.74±0 62	0.955 NS
Average digestibility coefficient of crude fat %	66.18±0.92	65.03±1 20	0.629 NS
Average digestibility coefficient of crude fibre %	61.28±1.52	63.75±1.09	1.262 NS
Average digestibility coefficient of nitrogen free extract %	66.29±0.93	66.89±0 66	0.517 NS
Average digestibility coefficient of gross energy	66.62±0.91	67.24±0.82	0.488NS

* Significant at 1% level
NS - Not significant

Table 32

Summarised data on average daily DM intake (g) per $W_{kg}^{0.75}$

Animal number	Group A Average daily DM intake ($g/W_{kg}^{0.75}$)	Animal number	Group B Average daily DM intake ($g/W_{kg}^{0.75}$)	t value A vs B
1.	106.71±1.27	9.	105.61±1.59	
2.	105.29±1.50	10	115.63±1.41	
3.	111.03_1.52	11.	105.74±1.74	
4.	107.57±1.33	12.	101.47±3.87	
5.	111.03±1.91	13.	97 90±1.65	
6.	109.90±1.96	14.	105.36±1.62	
7.	105.03±1.91	15.	115.98±1.24	
8.	108.08±1.98	16.	109.79±1.68	
Mean±SE	108.08±0.84		107.19±2.24	0.304 NS

Table 33

Summarised data on efficiency of utilization of DM for growth

Animal number	Group A Average DM intake (kg) per kg weight gain ±SE	Animal number	Group B Average daily DM intake (kg) per kg weight gain ±SE	t value A vs B
1.	15.56±1.37	9	15.31±1.04	
2.	14.60±1.26	10.	20.79±2.30	
3.	14 76±1.47	11	15.49±1.61	
4.	18.61±3.72	12.	11.36±0.71	
5.	12.76±0.99	13.	12.46±1.26	
6.	11.19+0 81	14.	13.80±0.92	
7.	12.80±1.59	15.	16.51±1.53	
8.	9 31±0.49	16.	12.65±1 05	
Mean±SE	13.70±1.01		14.80±1.06	0.771 NS

NS - Not significant

Table 34
Summarised data on fortnightly intake of gross energy (M cal)

Animal number	Group A Average fortnightly intake of gross energy (M cal)	Animal number	Group B Average fortnightly intake of gross energy (M cal)	t value A vs B
1.	295.25±7.59	9.	288.75±6.02	
2.	219.33±6.47	10.	280.39±7.35	
3.	257.92±9.43	11.	254.77±6.32	
4.	225.54±7.74	12.	263.76±8.47	
5.	238.06±7.94	13.	225.47±7.34	
6.	229.46±10.87	14.	218.28±6.79	
7.	205.44±7.79	15.	221.86±8.12	
8.	226.58±11.10	16.	210.24±8.95	
Mean±SE	237.20±9.85		245.44±10.73	0.843 NS

Table 35
Summarised data on average daily intake of gross energy (K cal) per $W_{kg}^{0.75}$

Animal number	Group A Average daily gross energy intake (K cal/$W_{kg}^{0.75}$)	Animal number	Group B Average daily gross energy intake(K cal/$W_{kg}^{0.75}$)	t value A vs B
1.	436.86±5.21	9.	432.93±6.63	
2.	435.43±6.64	10.	473.93±5.84	
3.	456.29±6.46	11.	433.79±7.30	
4	447.14±5.13	12	430.93±6 77	
5.	456.21±7.94	13.	405.25±7 22	
6.	430.29±7.27	14.	433.46±6.69	
7.	433.00±7.55	15.	477.14±5.54	
8.	444.00±8.11	16.	451.89±6.82	
Mean±SE	442.40±3.59		442.42±8.50	0 001 NS

NS - Not significant

Table 36

Summarised data on average gross energy intake (M cal) per kg weight gain

Animal number	Group A Average gross energy intake (M cal/kg weight gain)	Animal number	Group B Average gross energy intake (M cal/kg weight gain)	t value A vs B
1.	63.73±5.57	9.	62.72±4.25	
2.	56.79±3.20	10.	87.08±8.95	
3.	60.58±6.00	11.	63.66±6.59	
4.	62.03±6.14	12.	46.39±2.88	
5.	52.10±4.08	13.	51.44±5.17	
6.	44.77±3.51	14.	56.89±3.79	
7.	55.79±6.53	15.	69.08±6.24	
8.	38.22±2.02	16.	54.50±4.63	
Mean±SE	54.25±3.13		61.47±4.47	1.399 NS

Table 37

Summarised data on average fortnightly TDN intake (kg)

Animal number	Group A Average fortnightly TDN intake (kg)	Animal number	Group B Average fortnightly TDN intake (kg)	t value A vs B
1.	44.31±1.19	9.	43.01±1.05	
2.	32.15±0.99	10.	41.98±1.18	
3.	38.27±1.47	11.	38.04±1.00	
4.	33.07±1.16	12.	39.48±1.34	
5.	35.19±1.21	13.	33.36±1.08	
6.	35.00±1.47	14.	32.51±1.06	
7.	30.29±1.17	15.	33.05±1.26	
8.	33.51±1.68	16.	31.35±1.38	
Mean±SE	35.22±1.54		36.60±1.62	0.863 NS

NS - Not significant

Table 38

Summarised data on average daily TDN intake (kg)

Animal number	Group A Average daily TDN intake (kg)	Animal number	Group B Average daily TDN intake (kg)	t value A vs B
1.	3.17±0.09	9.	3.07±0.08	
2.	2.30±0.07	10.	3 00±0.08	
3.	2.73±0.10	11	2 72±0.07	
4.	2.36±0.08	12.	2.82±0.10	
5.	2 52±0.09	13.	2.38±0.08	
6.	2.50±0.10	14.	2.32±0.08	
7.	2.16±0.08	15.	2.36±0.09	
8.	2.39±0.12	16.	2.24±0.10	
Mean±SE	2.52±0.11		2 61±0.12	0.858 NS

Table 39

Summarised data on average daily intake of TDN (g) per $W_{kg}^{0.75}$

Animal number	Group A Average TDN intake g per $W_{kg}^{0.75}$	Animal number	Group B Average TDN intake g per $W_{kg}^{0.75}$	t value A vs B
1.	64.7±0.7	9.	64.3±0.9	
2.	63.9±0.9	10.	70.8±0.8	
3.	67.5±0.9	11.	64.6±1.0	
4.	65.0±0.9	12.	64.3±0.9	
5.	67.3±1.1	13.	59.9±0.9	
6.	66.2±1.0	14	64.4±0.9	
7.	63.8±1.1	15.	70.9±0.7	
8.	65.5±1 2	16.	67.2±1.0	
Mean±SE	65.5±0.5		65.8±1.3	0.180 NS

NS Not significant

Table 40
Summarised data on average TDN intake (kg) per kg body weight gain

Animal number	Group A Average TDN intake per kg weight gain (kg)	Animal number	Group B Average TDN intake per kg weight gain (kg)	t value A vs B
1.	9.46+0.84	9.	9.35+0 65	
2.	8,84+0.77	10.	13.06+1.36	
3.	9.00+0.90	11.	9.52+1.00	
4.	9.05+0.87	12.	6.94+0.44	
5.	7.73+0.61	13.	7.63+0.78	
6.	6.81+0.49	14.	8.47+0.57	
7.	8.19+0.97	15.	10.32+0.95	
8.	5 65+0.30	16.	8.03+0.70	
Mean+SE	8.09+0.46		9.17+0.68	1.474 NS

Table 41
Summarised data on fortnightly intake of digestible energy (M cal)

Animal	Group A Average fortnightly intake of digestible energy (M cal)	Animal number	Group B Average fortnightly intake of digestible energy (M cal)	t value A vs B
1.	198.89+5.14	9.	193.05+4.22	
2.	146.72+4.45	10	187.56+5.07	
3.	172.54+6.44	11.	170 40+4.36	
4.	150.90+5.31	12.	176.60+5.83	
5.	158.89+5.42	13.	150.83+5.03	
6.	153.61+7.40	14.	146.03+4.67	
7.	137.48+5.31	15.	148.45+5.55	
8.	151.70+7.56	16	140.69+6.09	
Mean+SE	158.84+6.73		164 20+7.17	0 816 NS

NS Not significant

Table 42
Summarised data on average daily intake of digestible energy (K cal) per $W_{kg}^{0.75}$

Animal number	Group A Average daily digestible energy intake (K cal/ $W_{kg}^{0.75}$)	Animal number	Group B Average daily digestible energy intake (K cal/ $W_{kg}^{0.75}$)	t value A vs B
1.	291.96±3 33	9	288.29±3 95	
2.	290.93±4.29	10	316.79±3.76	
3.	304.96±4.10	11.	289.82±4 61	
4.	296.54±3.68	12	288 04±4.28	
5.	304 86±5.06	13	270.75±4.66	
6.	287 57±4.79	14	289.57±4 24	
7.	289.36±4 85	15	318 89±3.58	
8.	296.75±5.30	16	302.04±4 46	
Mean±SE	295.37±2.37		295.52±5.71	0 022 NS

Table 43
Summarised data on average digestible energy intake (M cal) per kg weight gain

Animal number	Group A Average digestible energy intake (M cal/kg) weight gain	Animal number	Group B Average digestible energy in take (M cal/kg weight gain)	t value A vs B
1.	42.57±3 77	9	41.94±2 85	
2.	37.98±2.15	10	58 30±6.03	
3.	40.56±4.04	11	42 62±4.44	
4	41.52±4.14	12	31.04±1 95	
5	35.00±2 77	13.	34 79±3.47	
6.	29.98±2.38	14	38.04±2.55	
7	37 36±4 40	15	46 30±4.22	
8	25.58±1 37	16.	36.46±3 11	
Mean±SE	36 32±2.09		41 19±3 00	1 409 NS

NS Not significant

Table 44

Summarised data on average fortnightly intake of crude protein (kg)

Animal number	Group A Average fortnightly intake of crude protein (kg) ±SE	Animal number	Group B Average fortnightly intake of crude protein (kg) ±SE	t value A vs B
1.	9 43±0 16	9	9 20±0.14	
2.	7.51±0.21	10.	8.97±0.18	
3.	8 06±0.39	11.	8.42±0.17	
4.	7.66±0.23	12	8.59±0.23	
5.	10.39±2 48	13	7.71±0.21	
6.	7.82±0.29	14	7 48±0 22	
7.	7.15±0 27	15.	7.43±0 27	
8.	7.53±0.33	16	7.12±0.29	
Mean±SE	8.19±0.40		7 96±0.23	0 186 NS

Table 45

Summarised data on average daily crude protein intake (g) per $W_{kg}^{0\ 75}$

Animal number	Group A Average daily crude protein intake (g) per $W_{kg}^{0.75}$ ±SE	Animal number	Group B Average daily crude protein intake (g) per $W_{kg}^{0.75}$ ±SE	t value A vs B
1	13 91±0.27	9	13.86±0.29	
2	14.94±0 24	10.	15.25±0.24	
3	14 93±0.27	11.	14 40±0 30	
4	15 11±0.22	12	14 15±0 31	
5	15 20±0.31	13	13.93±0 28	
6	14 89±0.28	14	14.90±0 26	
7	14 95±0 24	15	15 90±0 16	
8	14.91±0.31	16.	15 39±0.21	
Mean±SE	14 86±0 14		14 72±0.27	0 521 NS

NS Not significant

Table 46

Summarised data on intake of crude protein (kg) per kg body weight gain

	Group A		Group B	t value
Animal number	Average fortnightly crude protein intake (kg/kg weignt gain) ±SE	Animal number	Average fortnightly crude protein intake (kg/kg weight gain) ±SE	A vs B
1.	2.01±0.16	9	2 01±0.13	
2	2.07±0 18	10	2 78±0 28	
3.	1.96±0.19	11	2.09±0.21	
4.	2.10±0.20	12	1.50±0.09	
5.	1.73±0.13	13.	1 75±0.17	
6.	1.53±0.10	14.	1.95±0.13	
7.	1.92±0.23	15	2.30±0.21	
8.	1.28±0.06	16.	1 84±0.15	
Mean±SE	1.83±0.10		2.03±0.14	1.333 NS

Table 47

Summarised data on fortnightly intake of DCP (kg)

	Group A		Group B	t value
Animal number	Average fortnightly intake of DCP (kg)	Animal number	Average fortnightly in take of DCP (kg)	A vs B
1	5.76±0 09	9	5.63±0.08	
2	4.58±0 12	10	5 47±0 11	
3.	5.11±0.15	11	5.10±0.11	
4.	4.66±0.14	12	5 24±0.13	
5	4 82±0.14	13	4 70±0.12	
6.	4 77±0.18	14	4 56±0.13	
7	4.32±0 15	15	4 51±0.16	
8.	4.59±0 20	16.	4.34±0 17	
Mean±SE	4.82±0 16		4 94±0 17	0.828 NS

NS Not significant

Table 48

Summarised data on average daily intake of DCP (g) per $W_{kg}^{0.75}$

Animal number	Group A Average daily DCP intake ($g/W_{kg}^{0.75}$)	Animal number	Group B Average daily DCP intake ($g/W_{kg}^{0.75}$)	t value A vs B
1.	8.49±0.17	9	8.47±0 18	
2.	9.12±0.15	10.	9.31±0 16	
3	9 11±0.17	11	8.79±0.19	
4.	9 22±0.14	12.	8.63±0 20	
5.	9.36±0.19	13.	8.51±0 18	
6.	9.10±0.18	14.	9 10±0 17	
7.	9 13±0 15	15.	9.70±0.10	
8	9.10±0.19	16	9 37±0 13	
Mean±SE	9 08±0 09		9 00±0 16	0 589 NS

Table 49

Summarised data on average intake of DCP (kg) per kg weight gain

Animal number	Group A Average DCP intake (kg/kg weight gain)	Animal number	Group B Average DCP intake (kg/kg weight gain)	t value A vs B
1.	1.22±0.10	9	1.22±0 08	
2.	1.19±0 07	10.	1.70±0.17	
3.	1 20±0.11	11	1.28±0 13	
4	1.28±0.12	12	0 92±0 05	
5	1 05±0 08	13.	1.07±0 10	
6.	0 93±0.06	14	1.19±0 08	
7	1 17±0 14	15	1 43±0 13	
8.	0.78±0 04	16	1 13±0 09	
Mean±SE	1 10±0.06		1 24±0 08	1.395 NS

NS Not significant

Table 50

Summarised data on nitrogen balance (g/day)

	Trial I			Trial II		
	Group A	GroupB	t value A vs B	Group A	Group B	t value A vs B
Number of animals	8	8		8	8	
Average total nitrogen intake (g/day)	97.692±2.52	99.420±2 84		108.684±3.33	110.212±2.87	
Average nitrogen excretion in dung (g/day)	37.798±1.17	38.532±1.69		43.448±0.95	43.186±0.82	
Average nitrogen excretion in urine (g/day)	41.416±2.06	42.824±1.33		47.337±2.86	48.170±1.42	
Average nitrogen balance (g/day)	18.48±0.61	18.06±1.02	0.507 NS	17.90±1.02	18.86±1.15	0 634NS
Average nitrogen retention as percentage of total intake	19.01±0.82	18.21±0 98		16.60±1 02	17.04±0.75	

NS - Not significant

Fig 1

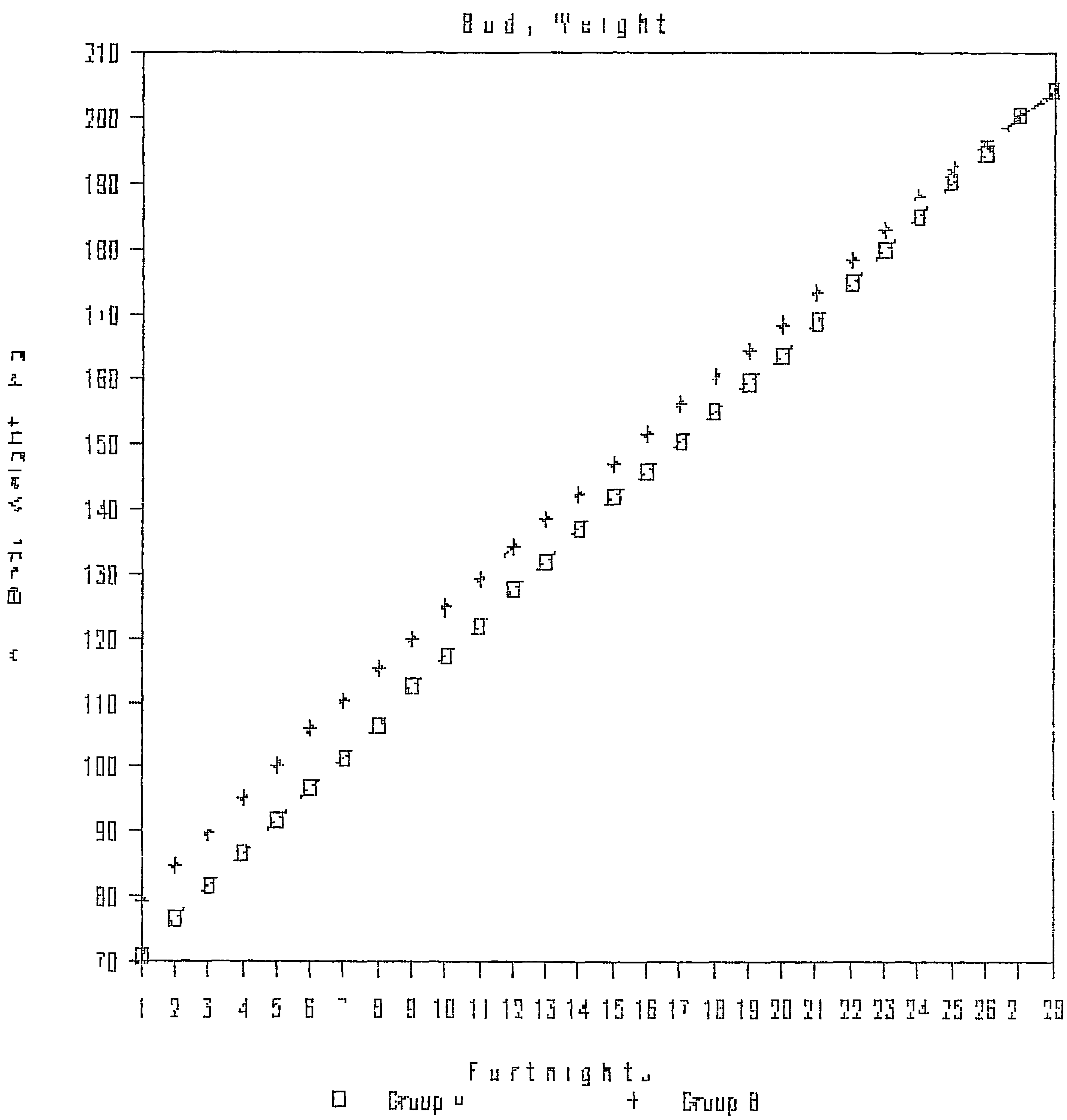
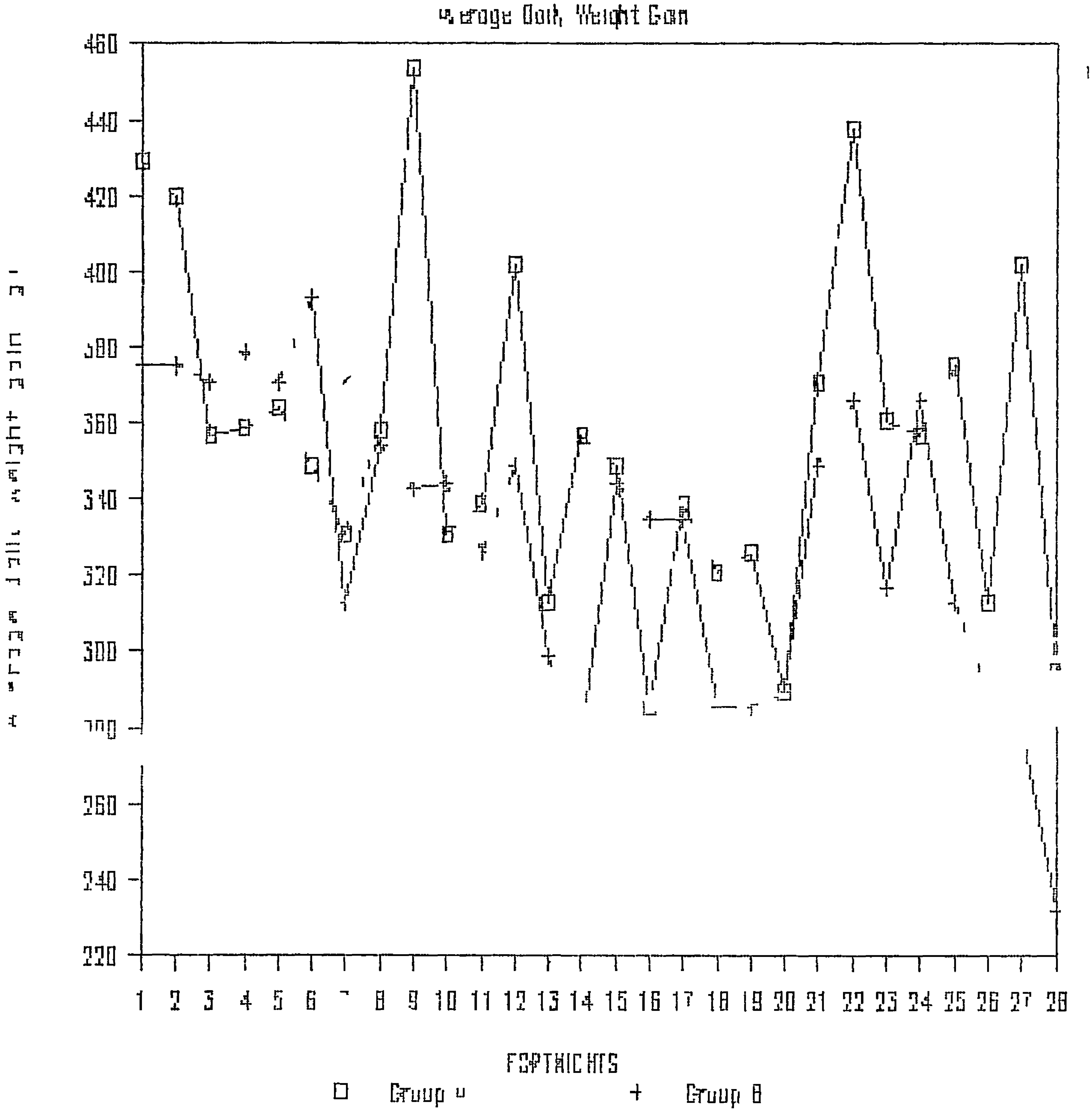


Fig 2


1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28
Group B

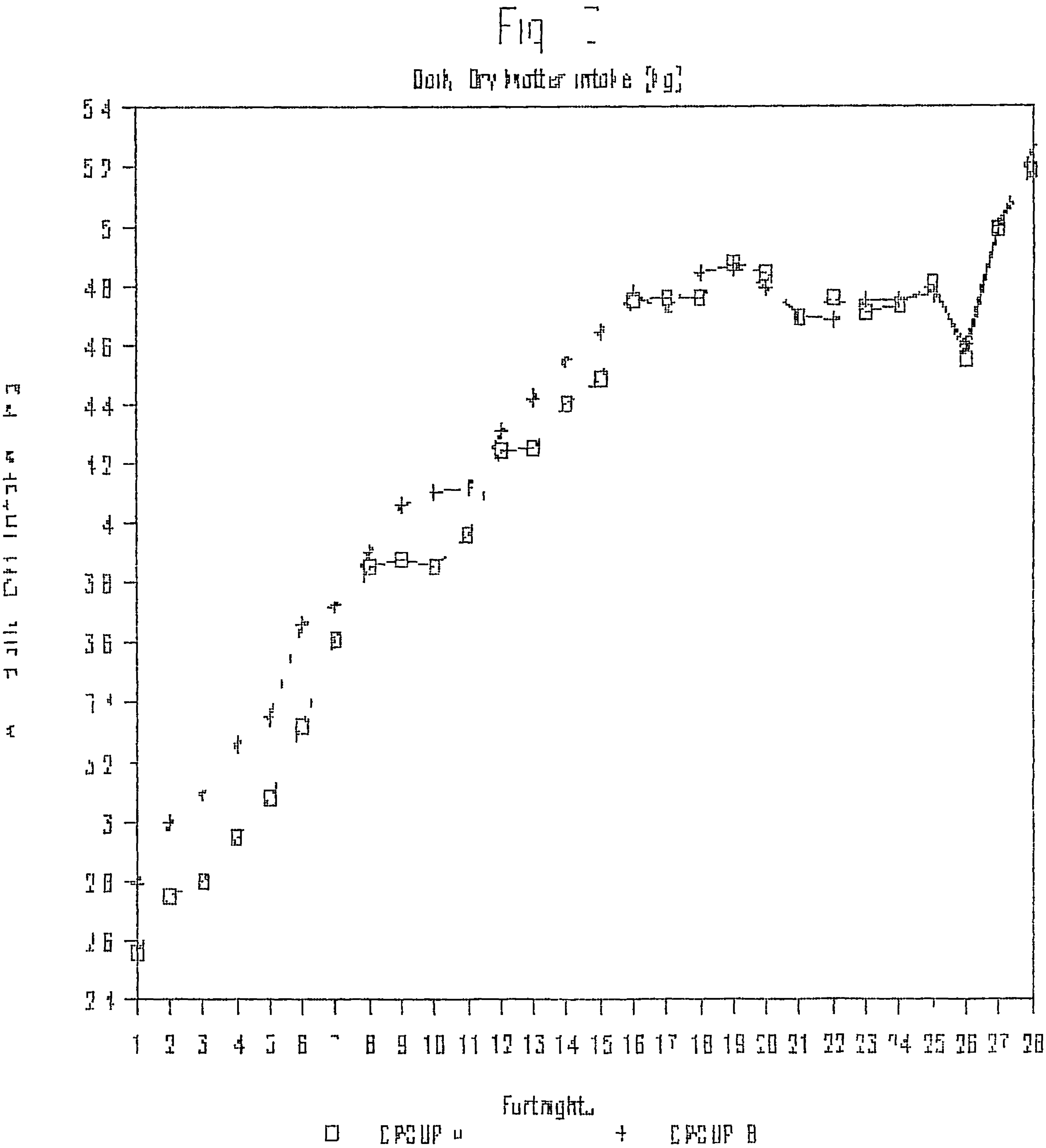


Fig 2
Daily Dry Matter intake (kg)
Fortnight
GROUP A
GROUP B

Fig 4

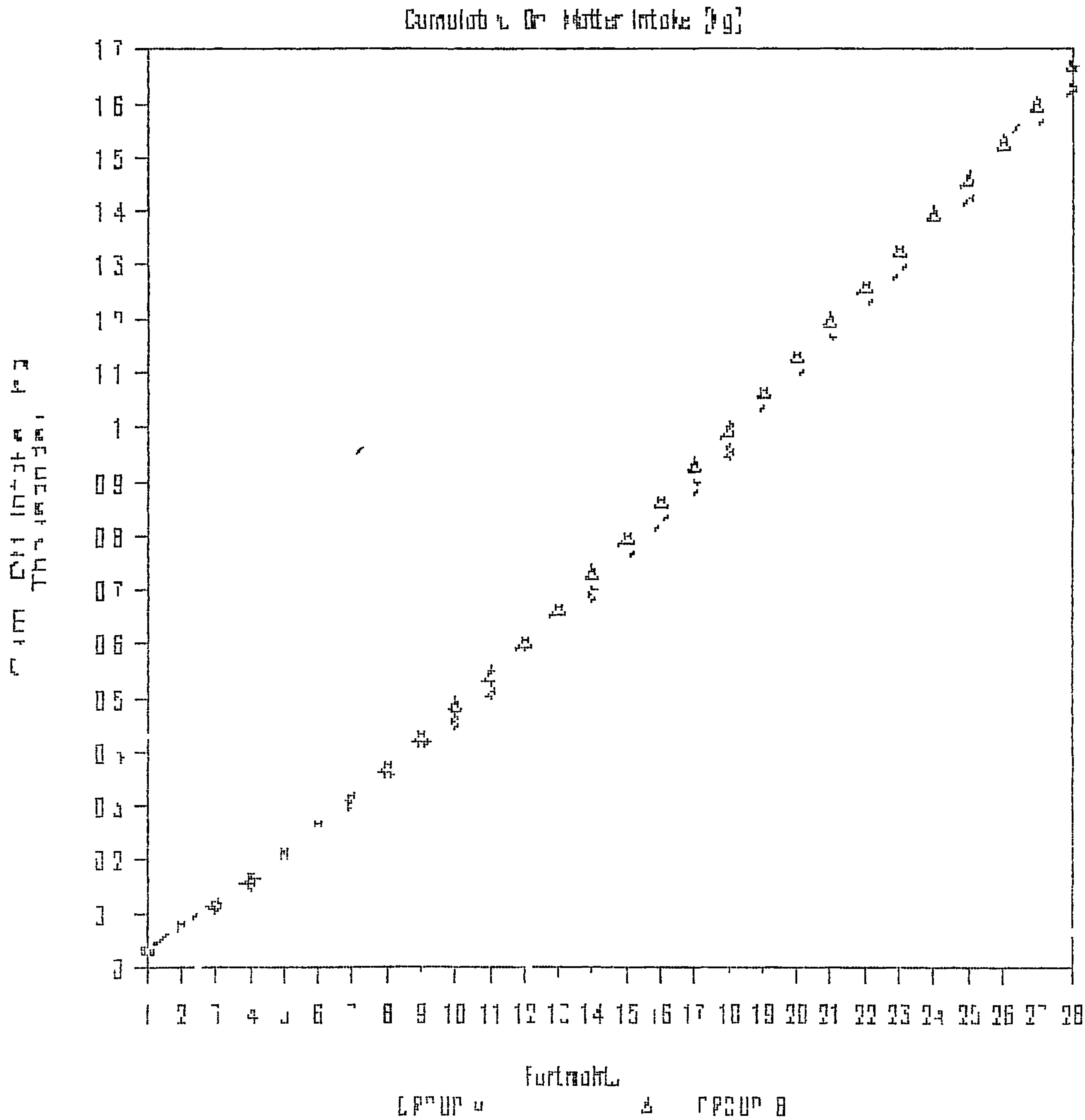


Fig 5

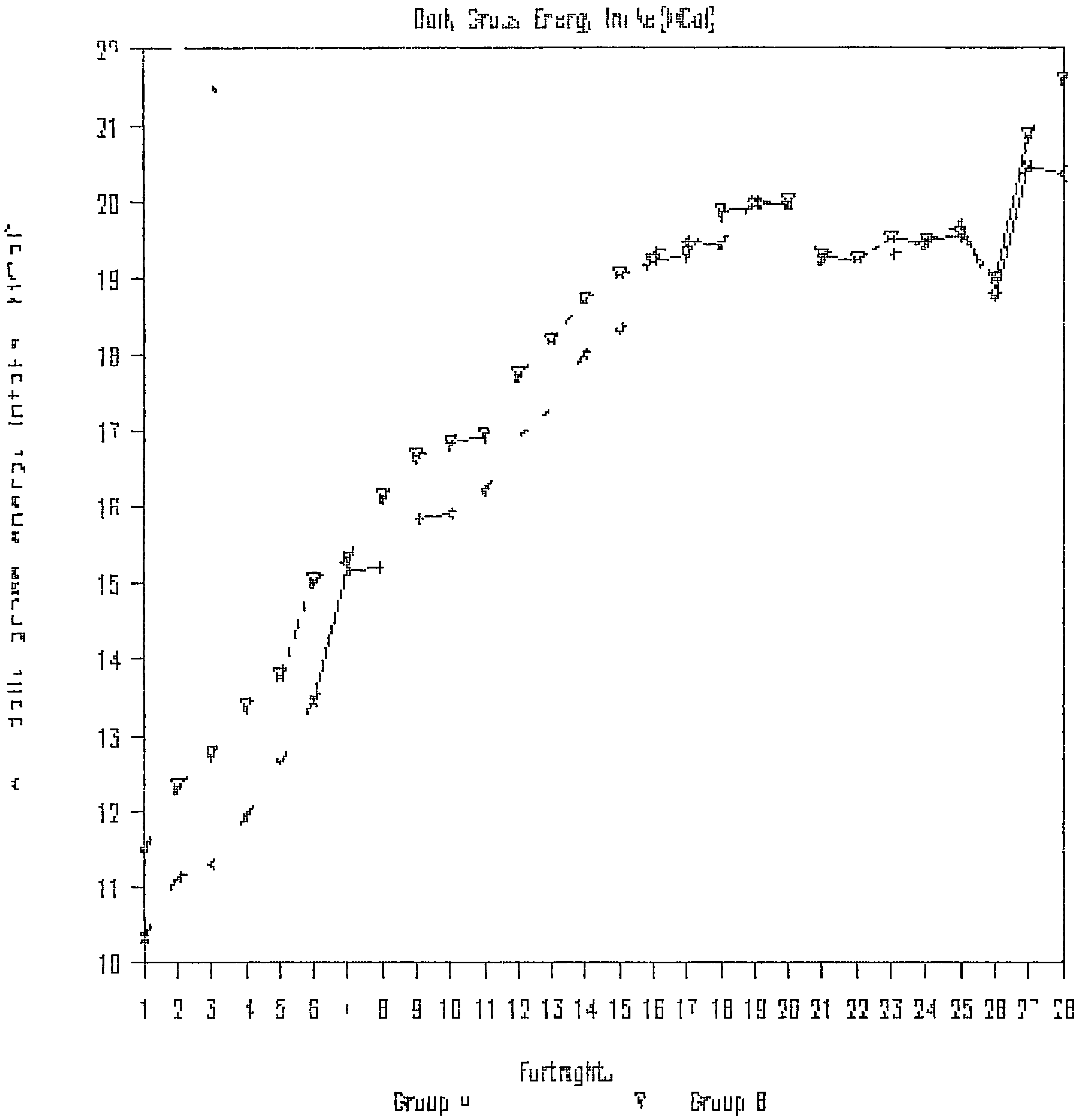


Fig 1h

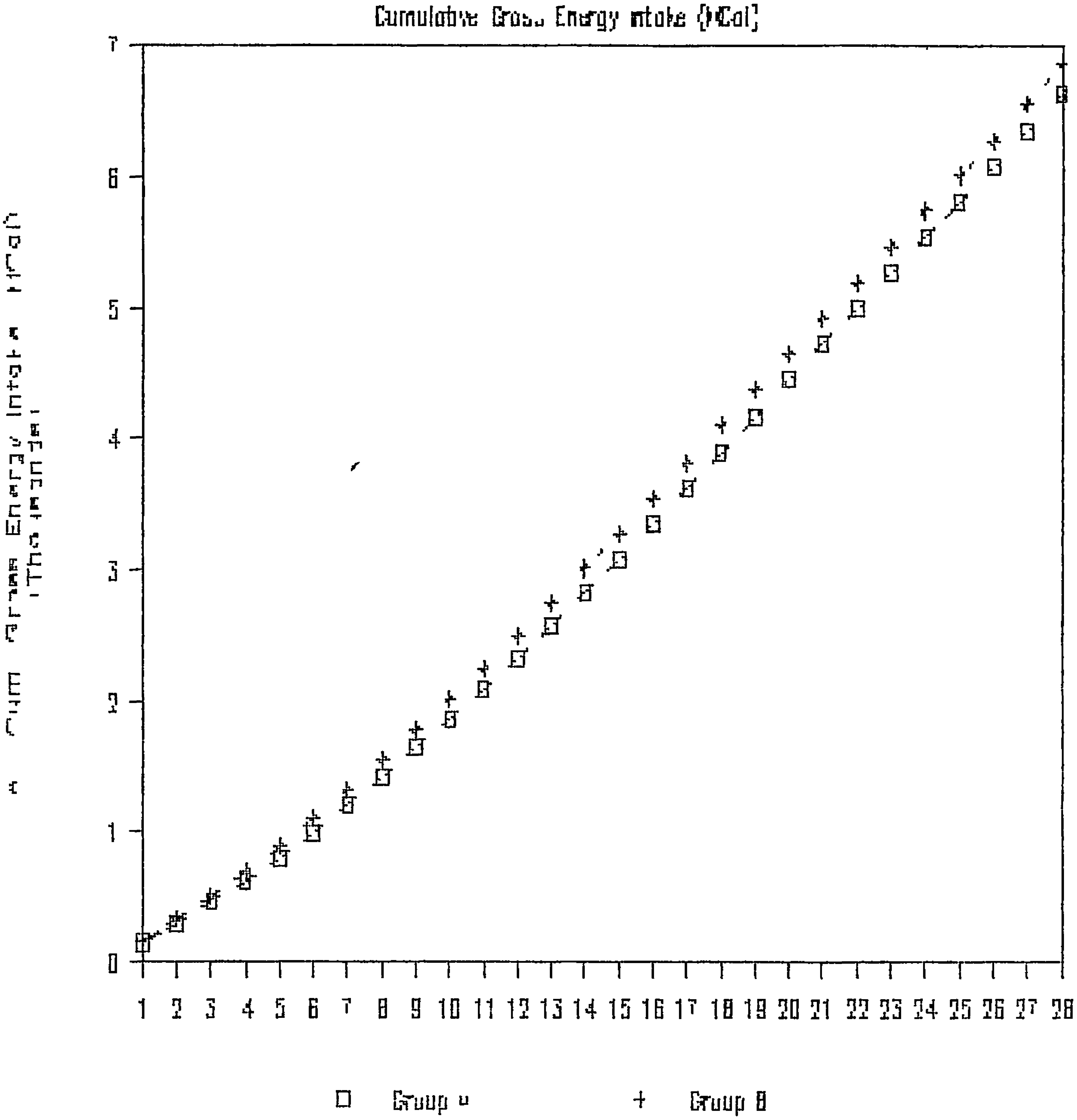

Cumulative Gross Energy Intake (MCal)
Cum. Gross Energy Intake (MCal)
(Thousands)
0
1
2
3
4
5
6
7
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28
Group A
Group B

Fig 7

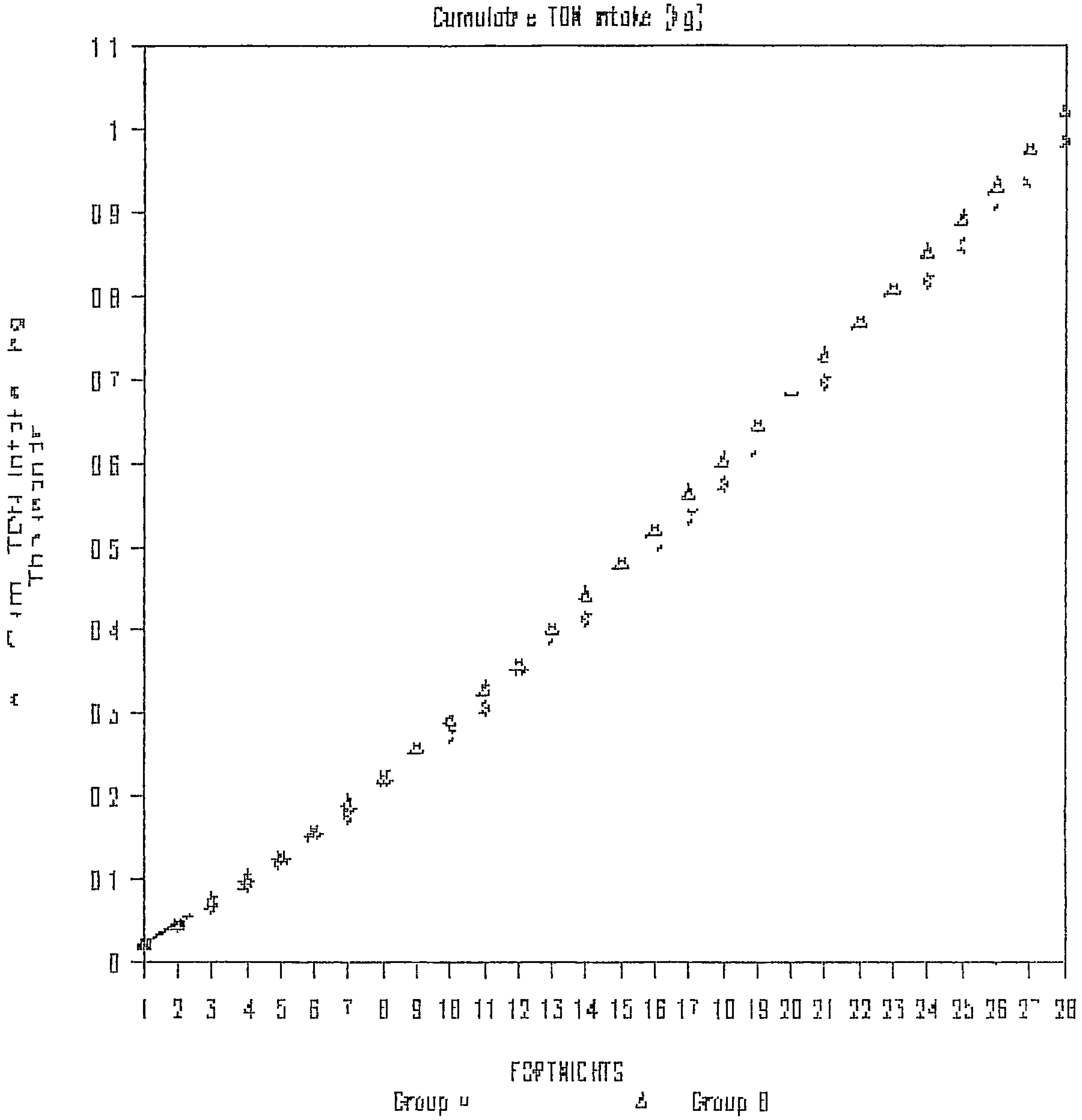


Fig 4

Cumulative Digestible Energy intake

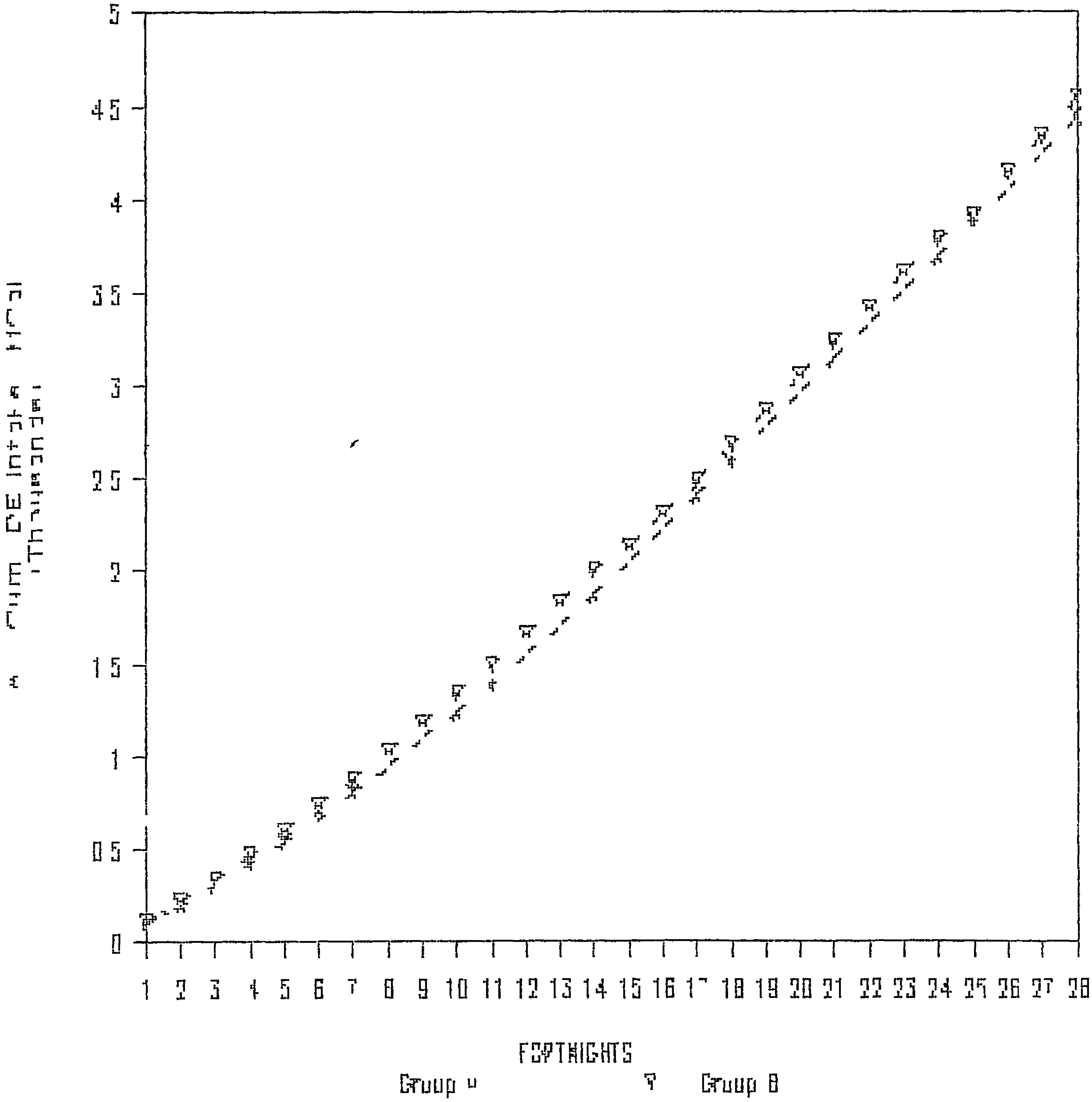
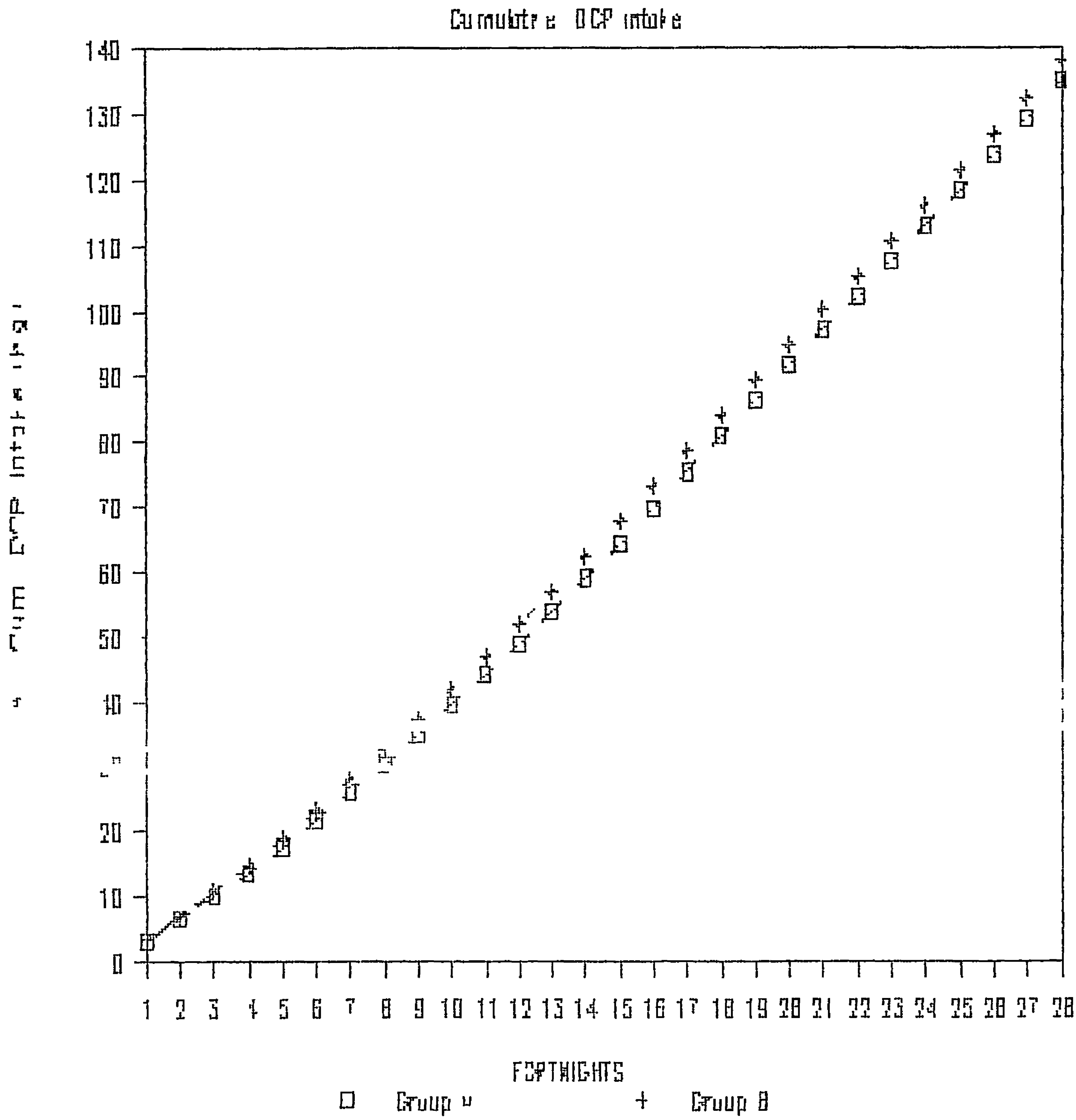


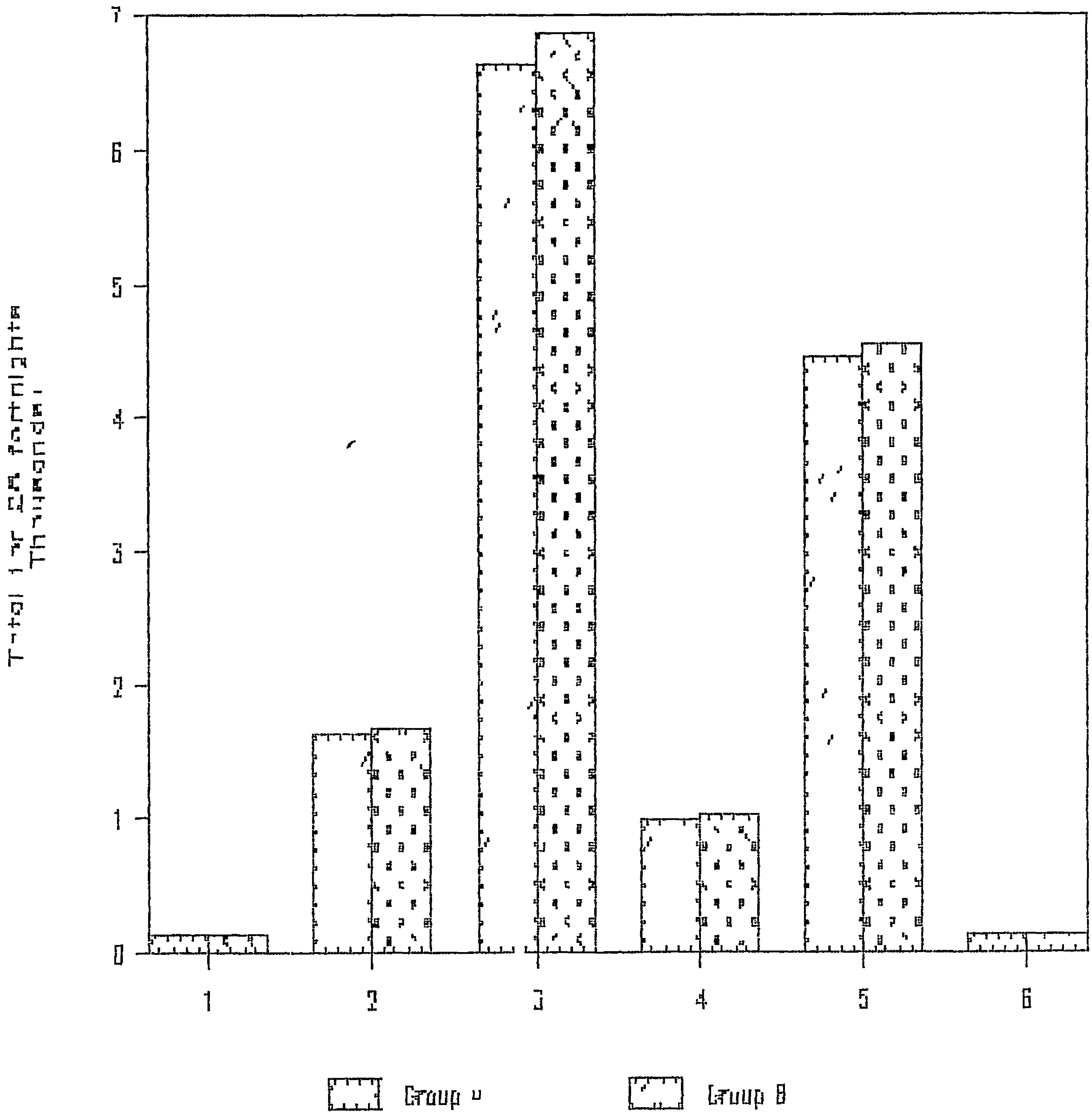
Fig 4



Cumulative OCP intake
0
10
20
40
50
60
70
80
90
100
110
120
130
140
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28
FORTNIGHTS
Group B

Fig 10

Feed Utilisation for Growth



1. Weight gain (kg)
2. Dry matter intake
3. Gross energy intake (Mcal)
4. TDN intake (kg)
5. Digestible energy intake (Mcal)
6. DCP intake (kg)

Part II

LACTATION STUDY

Table 51
Summarised data on fortnightly body weight and weight gain (kg)

	Average fortnightly body weight (kg+SE)		Average fortnightly weight gain (kg+SE)	
	Group A	Group B	Group A	Group B
Initial	266.75+8.18	273.92+16.30		
1.	266.00+8 48	275.75+16.13	1.25+0.84	1.67+0.36
2	268.58+8.12	277.83+16.20	0 58+0.74	2.08+0.42
3.	270.17+8.11	279.58+16.00	1.58+0.24	1.58+0.27
4	2 72 17+8.17	281.58+16.06	2.00+0.47	2.00+0.43
5.	273.58+8.39	283.17+15.95	1.42+0 52	1.58+0.27
6.	274.83+8.50	284.75+15.88	1.25+0 68	1.58+0.20
7.	276.33+8.61	286.42+15.93	1.50+0.48	1.67+0 40
8.	277 42+8.88	288.17+15.94	1 08+0.49	1.75+0.57
9	279.83+8.91	290.08+16.11	2.42+0.27	1.92+0.27
10.	280.92+9.51	291.50+16.55	1.08+0.90	1.42+0.79
11.	281.83+10.01	293.17+16.72	0.92+0.64	1.67+0.25
12.	283.42+9.99	295.17+16.95	1.58+0.20	2.00+0.39
13.	285.50+9.96	296.50+17.21	2.08+0.24	1 33+0.31

Table 52

Statistical analysis of fortnightly data on body weight
A N O C O V A (Ist fortnight)

SOURCE	DF	SXX	SXY	SYY
Treatment	1	154.13	166.63	180.19
Error	10	9972.06	9953.87	9961 38
Total	11	10126.19	10120.50	10141 56
Treatment + Error	11	10126.19	10120.50	10141.56

Estimate of Reg Coefficient (b cap) .9982
Adj Error - 25.6543 with 9 df
Adj.(Treat. + Error) 26.7471 with 10 df
Adjusted Treat. - 1.0928 with 1 df
F - 3834 with 1 and 9 df NS

NS Not significant

Table 53
Statistical analysis of fortnightly data on body weight
A N O C O V A (7th fortnight)

SOURCE	DF	SXX	SXY	SYY
Treatment	1	154.13	216 81	305 00
Error	10	9972.06	9718 19	9831.56
Total	11	10126.19	9935 00	10136 56
Treatment + Error	11	10126.19	9935.00	10136.56

Estimate of Reg.Coefficient (b cap) = .9745
Adj. Error - 360.7871 with 9 df
Adj. (Treat. + Error) 389.1407 with 10 df
Adjusted Treat. - 28.3535 with 1 df
F = .7073 with 1 and 9 df (NS)

Table 54

Statistical analysis of fortnightly data on body weight
A N O C O V A (13th fortnight)

SOURCE	DF	SXX	SXY	SYY
Treatment	1	154.13	236.50	363.00
Error	10	9972.06	10353.00	11863.00
Total	11	10126.19	10589.50	12226.00
Treatment + Error	11	10126.19	10589 50	12226.00

Estimate of Reg.Coefficient (b cap) - 1.0382
Adj.Error - 1114.5107 with 9 df
Adj.(Treat. + Error) - 1151 9893 with 10 df
Adjusted Treat. - 37.4785 with 1 df
F - .3026 with 1 and 9 df (NS)

NS - Not significant

Table 55

Statistical analysis of fortnightly data on body weight gain
A N O V A T A B L E (2ndfortnight)

SOURCE	DF	SS	MSS	F
Treatment	1	6.750	6.750	3.152 NS
Error	10	21.417	2.142	
Total	11	28.167		

SE of the different between treatment 1 and 2 .84492

CD at 5% level 1.88248 CD at 1% level - 2.67755

Table 56

Statistical analysis of fortnightly data on body weight gain
A N O C O V A (7th fortnight)

SOURCE	DF	SXX	SXY	SYY
Treatments	1	.52	.21	.08
Error	10	25.21	12.83	11.83
Total	11	25.73	13.04	11.92
Treatment + Error	11	25.73	13.04	11.92

Estimate of Reg.Coefficient (b cap) - .5091
Adj. Error - 5 3000 with 9 df
Adj. (Treat. + Error) - 5.3061 with 10 df
Adjusted Treat. - .0061 with 1 df
F - .0103 with 1 and 9 df NS

NS Not significant

Table 57

Statistical analysis of fortnightly data on body weight gain

ANOVA TABLE (13th fortnight)

SOURCE	DF	SS	MSS	F
Treatment	1	1.687	1.687	3.716 NS
Error	10	4.542	.454	
Total	11	6.229		

SE of the difference between treatment 1 and 2 - .38909

CD at 5% level = .86689 CD at 1% level = 1.23302

NS - Not significant

Table 58

Summarised data on fortnightly intake of concentrate and roughage (kg)

	Average fortnightly intake of concentrate (kg+SE)		Average fortnightly intake of roughage (kg+SE)	
	Group I	Group II	Group I	Group II
1.	60.09±3.55	60.75±2.74	448.13±13.47	451.62±21.94
2.	60.08±3.55	60.75±2.74	446.99±12.50	433.47±21 64
3.	59.92±3.05	60.75±2.74	396.16±12.49	388.33±20.37
4.	58.92±3.05	60.75±2.74	424.59±15.13	424.58±17.47
5.	58.92±3 05	60.75±2.74	417.21±11.08	415.33±18.14
6.	58.92±3.05	60.75±2.74	382.38±14.37	383.75±19.00
7.	58.92±3.05	60.75±2.74	389.54±18.22	393.42±18.98
8.	58.92±3.05	60.08±3.31	382.13±16.77	392.46±18.92
9.	57.75±2.96	60.08±3.31	392.46±12.79	385.38±22 53
10.	53.67±2.66	59.50±3.83	400.13±16.43	412.13±16.70
11.	52.50±2 39	56.00±3.00	410.46±16.84	414.92±21 39
12.	53.08±2.10	56.58±4.82	388.42±16.46	396.04±16.84
13.	55.42±2.10	56 58±4.82	425.33±14.74	425.13±18.71

Table 59
Statistical analysis of fortnightly data on concentrate intake
A N O C O V A (13th fortnight)

SOURCE	DF	SXX	SXY	SYY
Treatments	1	1.34	2.34	4 08
Error	10	603.08	538.41	828.92
Total	11	604.42	540.75	833.00
Treatment + Error	11	604.42	540.75	833.00

Estimate of Reg. Coefficient (b cap) .8928

Adj. Error - 348.2376 with 9 df

Adj. (Treat. + Error) - 349.2114 with 10 df

Adjusted Treat. - .9737 with 1 df

F - .0252 with 1 and 9 df (NS)

NS - Not significant

Table 60

Statistical analysis of fortnightly data on roughage intake
A N O C O V A (2nd fortnight)

SOURCE	DF	SXX	SXY	SYY
Treatments	1	37.00	-141.25	549.00
Error	10	19876.75	18641.50	18737.75
Total	11	19913.75	18500.25	19286.75
Treatment + Error	11	19913.75	18500.25	19286.75

Estimate of Reg. Coefficient (b cap) .9379
Adj. Error 1254.7342 with 9 df
Adj. (Treat. + Error) - 2099.6680 with 10 df
Adjusted Treat. = 844.9337 with 1 df
F - 6.0606* with 1 and 9 df

Table 61

Statistical analysis of fortnightly data on roughage intake
A N O C O V A (7th fortnight)

SOURCE	DF	SXX	SXY	SYY
Treatments	1	37.00	40.75	45.00
Error	10	19876 75	18459.00	20760.62
Total	11	19913.75	18499.75	20805.62
Treatment + Error	11	19913.75	18499.75	20805.62

Estimate of Reg.Coefficient (b cap) - .9287
Adj.Error - 3618.2506 with 9 df
Adj. (Treatment + Error) = 3619.4725 with 10 df
Adjusted Treat. 1.2227 with 1 df
F - .0030 with 1 and 9 df (NS)

* Significant at 5% level
NS Not significant

Table 62
Statistical analysis of fortnightly data on roughage intake
A N O C O V A (13th fortnight)

SOURCE	DF	SXX	SXY	SYY
Treatments	1	37.00	-2.00	.00
Error	10	19876.75	16256.50	17024.25
Total	11	19913.75	16254.50	17024.25
Treatment + Error	11	19913.75	16254.50	17024.25

Estimate of Reg. Coefficient (b cap) - .8179

Adj. Error = 3728.6264 with 9 df

Adj. (Treatment + Error) = 3756.5948 with 10 df

Adjusted Treat. - 27.9688 with 1 df

F - .0675 with 1 and 9 df (NS)

NS - Not significant

Table 63

Summarised data on dry matter consumption and roughage concentrate ratio

	Average fortnightly dry matter intake (kg±SE)		Average daily DM intake /100 kg body weight (kg±SE)		Average roughage concentrate ratio on DM basis(kg±SE)	
	Group I	Group II	Group I	Group II	Group I	Group II
1.	145.36±5.48	146.68±6 68	3 92±0.22	3.90±0 29	1.63±0.08	1.54±0.09
2.	145.22±5.29	143.17±6.63	3.90±0.23	3.77±0.26	1.63±0.08	1.54±0.04
3.	137.15±4.80	137.15±6.55	3.68±0.21	3.59±0.26	1.58±0.07	1.50±0.04
4.	150.26±5 21	151.91±6.27	4.00±0.21	3.96±0.30	1.84±0.10	1.77±0.04
5.	150.66±4.65	151.88±6.62	3.98±0.21	3.93±0.29	1.85±0.09	1.77±0.03
6.	153 46±5 95	155.48±7.34	4.04±0.24	4.00±0.30	1.89±0.08	1.83±0.03
7.	153.03±6.70	155.68±7.29	4.01±0.26	3.98±0.30	1.87±0.09	1.82±0.02
8.	155.68±6.59	159 50±7.91	4.06±0.26	4.05±0.31	1.92±0.08	1.93±0.05
9.	152.89±5.36	153.19±8.04	3.97±0.23	3.88±0.34	1.94±0.08	1.82±0.09
10.	152.34±6.14	160.75±7.70	3.92±0.24	4.04±0.32	2.14±0.08	2.00±0.07
11	155 13±6.32	159.49±8.17	3.98±0.24	3.99±0.33	2.24±0.06	2.12±0.05
12.	152 47±6.15	157.72±8 87	3.90±0.25	3.94±0.36	2.14±0 05	2.10±0.13
13	153 45±5.19	156.30±8 99	3.90±0.23	3 87±0.34	2.05±0.05	2.09±0.15

Table 64
Statistical analysis of fortnightly data on dry matter intake
A N O C O V A (2nd fortnight)

SOURCE	DF	SXX	SXY	SYY
Treatments	1	5.27	-8.08	12.70
Error	10	2240.87	2171.41	2156.75
Total	11	2246.14	2163.33	2169.45
Treatment + Error	11	2246.14	2163.33	2169.45

Estimate of Reg.coefficient (b cap) = .9690
Adj. Error = 52.6589 with 9 df
Adj. (Treat. + Error) = 85.8843 with 10 df
Adjusted Treat. = 33.2253 with 1 df
F = 5.6706* with 1 and 9 df

Table 65
Statistical analysis of fortnightly data on dry matter intake
A N O C O V A (7th fortnight)

SOURCE	DF	SXX	SXY	SYY
Treatments	1	5.27	10.50	21.12
Error	10	2240.87	2483.59	2939.75
Total	11	2246.14	2494.09	2960.88
Treatment + Error	11	2246.14	2494.09	2960.88

Estimate of Reg.Coefficient (b cap) - 1.1083
Adj. Error = 187.1475 with 9 df
Adj. (Treatment + Error) = 191.4565 with 10 df
Adjusted Treat. = 4.3091 with 1 df
F = .2072 with 1 and 9 df (NS)

Significant at 5% level
- Not significant

Table 66
Statistical analysis of fortnightly data on dry matter intake
A N O C O V A (13th fortnight)

SOURCE	DF	SXX	SXY	SYY
Treatments	1	5.27	11.31	24.47
Error	10	2240.87	2429.94	3229.69
Total	11	2246.14	2441.25	3254 16
Treatment + Error	11	2246.14	2441.25	3254.16

Estimate of Reg.Coefficient (b cap) - 1.0844
Adj. Error - 594.7361 with 9 df
Adj. (Treat. + Error) - 600.8489 with 10 df
Adjusted Treat. - 6.1128 with 1 df
F = 0925 with 1 and 9 df (NS)

Table 67
Statistical analysis of fortnightly data on average daily dry matter intake (kg) per 100 kg body weight
A N O C O V A (2nd fortnight)

SOURCE	DF	SXX	SXY	SYY
Treatments	1	.00	.01	.05
Error	10	3.96	3.78	3.67
Total	11	3.96	3.79	3.72
Treatment +Error	11	3.96	3.79	3.72

Estimate of Reg Coefficient (b cap) - .9553
Adj. Error - .0581 with 9 df
Adj. (Treat. + Error) - .0920 with 10 df
Adjusted Treat. .0339 with 1 df
F = 5.2461* with 1 and 9 df

* Significant at 5% level
NS Not significant

Table 68

Statistical analysis of fortnightly data on average daily dry matter intake (kg) per 100 kg body weight

A N O C O V A (7th fortnight)

SOURCE	DF	SXX	SXY	SYY
Treatments	1	.00	.00	.00
Error	10	3.96	4.18	4.61
Total	11	3.96	4.18	4.62
Treatment +Error	11	3.96	4.18	4.62

Estimate of Reg. Coefficient (b cap) = 1.0567
Adj. Error = .1928 with 9 df
Adj. (Treat. + Error) = .1930 with 10 df
Adjusted Treat. - .0002 with 1 df
F - .0081 with 1 and 9 df (NS)

Table 69

Statistical analysis of fortnightly data on average daily dry matter intake (kg) per 100 kg body weight

A N O C O V A (13th fortnight)

SOURCE	DF	SXX	SXY	SYY
Treatments	1	.00	.00	.00
Error	10	3.96	4 34	5.07
Total	11	3.96	4 34	5.08
Treatment + Error	11	3.96	4.34	5.08

Estimate of Reg. Coefficient (b cap) 1.0965
Adj.Error - .3163 with 9 df
Adj. (Treat. + Error) -.3165 with 10 df
Adjusted Treat. - .0002 with 1 df
F = .0069 with 1 and 9 df NS

NS - Not significant

Table 70

Statistical analysis of fortnightly data on roughage concentrate ratio of ration on DM basis

A N O V A (13th fortnight)

SOURCE	DF	SS	MSS	F
Treatment	1	.005	.005	.076 NS
Error	10	712	.071	
Total	11	.718		

SE of the difference between treatment 1 and 2 .15408

CD at 5% level - .34329 CD at 1% level = .48828

Table 71

Summarised data on digestion coefficients of nutrients

	Group I	Group II	t values I vs II
Number of animals	6	6	
Average digestibility coefficients of DM (%)+SE	52.54+1.97	51.97+1 61	0.160 NS
Average digestibility coefficient of Crude protein (%)+SE	60.73+1.26	60.05+1.89	0.283 NS
Average digestibility coefficient of Crude fat (%) +SE	57.66+2.15	56.35+2.42	0.402 NS
Average digestibility coefficient of Crude fibre (%) +SE	51.11+2.43	49.81+1.21	0.372 NS
Average digestibility coefficient of Nitrogen free extract(%)+SE	60.44+1.82	59.99+1.77	0.126 NS
Average digestibility coefficient of Gross energy (%)+SE	55.40+1.97	55.81+1.79	0.112 NS

NS - Not significant

Table 72
Summarised data on fortnightly haematological values
Red cell, haemoglobin and plasma protein

Fort nights	Average Red blood cell (million per mm^3±SE)		Average haemoglobin (g per 100 ml±SE)		Average plasma protein (g per 100 ml ±SE)	
	Group I	Group II	Group I	Group II	Group I	Group II
1.	9.71±0.33	9.29±0.29	10.10±0.42	10.23±0.32	7.09±0.11	7.04±0.15
2.	9.42±0.17	9.88±0.09	10.57±0.30	10.77±0.27	7.18±0.16	7.39±0.15
3.	9.63±0.30	9.31±0.24	10.55±0.29	10.35±0.36	7.51±0.12	7.18±0.17
4.	9.38±0.16	9.63±0.24	10.18±0.18	10.60±0.30	7.68±0.23	7.75±0.15
5	9.52±0.23	9.43±0.21	10.25±0.26	10.15±0.29	7.75±0.13	7.53±0.22
6.	9.34±0.23	9.65±0.30	10.32±0.32	10.62±0.28	7.76±0.15	7.72±0.34
7.	9.49±0.27	9.58±0.27	10.47±0.32	10.32±0.33	8.06±0.27	7.44±0.22
8	9.79±0.37	9.29±0 26	10.05+0.32	10.53±0.38	7.44±0.32	7.41±0.26
9.	9 26±0.33	9.19±0.48	10.28±0.46	10.03±0.39	7.41±0.23	7.68±0.33
10	9.50±0.27	9.51±0.28	10.42±0.28	10.15±0.28	7.96±0.23	7.39±0.23
11.	9.80±0.45	9.37±0.21	10.08±0.24	10.50±0.26	7.76±0.16	7.70±0.29
12.	9.89±0.14	9.30±0.20	10.18±0.29	10.03±0.19	8.07±0.14	7.48±0.22
13.	9.67±0.29	9.23±0.15	10.12±0.34	10.38±0.21	7.72±0.23	7.72±0.27

Table 73

Statistical analysis of fortnightly data on haematological values - Red blood cells

A N O V A T A B L E S (13th fortnight)

SOURCE	DF	SS	MSS	F
Treatment	1	.594	.594	1.857 NS
Error	10	3.199	.320	
Total	11	3.793		

SE of the difference between treatment 1 and 2 = .32654

CD at 5% level - .72753 CD at 1% level - 1.03481

Table 74

Statistical analysis of fortnighly data on haematological values - Haemoglobin concentration

A N O V A T A B L E (13th fortnight)

SOURCE	DF	SS	MSS	F
Treatment	1	.213	.213	450 NS
Error	10	4.736	.474	
Total	11	4.950		

SE of the difference between treatment 1 and 2 = .39734

CD at 5% level - .88528 CD at 1% level - 1.25918

NS - Not significant

Table 75
Statistical analysis of fortnightly data on haematological values - Plasma protein concentration

A N O V A T A B L E (13th fortnight)

SOURCE	DF	SS	MSS	F
Treatment	1	.000	.000	.000 NS
Error	10	3.721	.372	
Total	11	3.721		

SE of the difference between treatment 1 and 2 - .35220

CD at 5% level - .78471 CD at 1% level - 1.11614

Table 76
Summarised data on fortnightly milk yield

Fortnights	Average fortnightly milk yield (kg±SE) Group I	Group II
1.	101.92±6.75	99.00±4.80
2.	104.50±6.14	99.93±3.87
3.	100.07±4.54	99.32±6 02
4.	95.95±4.79	99.32±4.52
5.	100 32±4.71	102.92±4.96
6.	103.92±4.15	105.68±5.58
7.	98.88±3.44	99.18±5.32
8.	95.37±2.33	96.78±5.61
9.	85.48±1.41	92.35±4.77
10.	81.43±2 39	84.17±3.65
11.	80 05±6.15	90.08±7.34
12.	90.17±5.76	94.85±8.48
13.	89.95±6.40	95.18±8.72

NS - Not significant

Table 77
Statistical analysis of fortnightly data on milk yield
A N O C O V A (2nd fortnight)

SOURCE	DF	SXX	SXY	SYY
Treatments	1	25.52	39.97	62.58
Error	10	2060.05	1770.20	1580.93
Total	11	2085.57	1810.16	1643.51
Treatment + Error	11	2085.57	1810.16	1643.51

Estimate of Reg.Coefficient (b cap) .8593
Adj. Error - 59.8033 with 9 df
Adj. (Treat.+Error) - 72.3817 with 10 df
Adjusted Treat. - 12.5784 with 1 df
F - 1.8930 with 1 and 9 df (NS)

Table 78
Statistical analysis of fortnightly data on milk yield
A N O C O V A (7th fortnight)

SOURCE	DF	SXX	SXY	SYY
Treatments	1	25.52	-2.62	.28
Error	10	2060.05	1322.91	1202 23
Total	11	2085.57	1320.28	1202.52
Treatment +Error	11	2085.57	1320.28	1202.52

Estimate of Reg.Coefficient (b cap) - .6422
Adj.Error - 352.6998 with 9 df
Adj. (Treat.+Error) - 366.7046 with 10 df
Adjusted Treat. - 14.0048 with 1 df
F - .3574 with 1 and 9 df (NS)

NS - Not significant

Table 79
Statistical analysis of fortnightly data on milk yield
A N O V A T A B L E (13th fortnight)

SOURCE	DF	SS	MSS	F
Treatment	1	82.164	82.164	.234 NS
Error	10	3508.414	350.841	
Total	11	3590.578		

SE of the different between treatment 1 and 2 - 10.81421
CD at 5% level = 24.09406
CD at 1% level - 34.27023

NS - Not significant

Table 80
Summarised data on fortnightly composition of milk

Fort-nights	Total solids (g per 100 g ±SE)		Solids not fat (g per 100 g±SE)		Fat (g per 100 g ±SE)		Protein (g per 100 g±SE)	
	Group I	Group II	Group I	Group II	Group I	Group II	Group I	Group II
1.	13.12±0.19	12.70±0.12	8.17±0.19	7.95±0.08	4.95±0.20	4.75±0.15	3.51±0.03	3.49±0.03
2.	13.40±0.21	13.33±0.15	8.45±0.19	8.47±0.14	4.95±0.09	4.87±0.07	3.44±0.06	3.49±0.01
3.	13.82±0.35	13.42±0.11	8.54±0.39	8.49±0.24	5.28±0.15	4.93±0.20	3.52±0.04	3.50±0.03
4.	13.31±0.30	12 74±0.22	8 41±0.28	8.20±0.23	4.90±0.25	4.53±0.23	3.54±0.17	3.72±0.07
5	13 48+0.14	13.29±0.15	8.39±0.12	8.25±0.15	5.08±0.10	5.03±0.07	3.50±0.01	3.46±0.01
6	13.60±0.14	13.06±0.14	8.56±0.15	8.28±0.15	5.03±0.05	4.78±0.08	3.46±0.02	3.48±0.01
7.	13 26±0.17	13.12±0.12	8.26±0.22	8.17±0.14	5.00±0.06	4.95±0.07	3.53±0.04	3.46±0.04
8.	13.29±0.12	13.08±0.14	8.19±0.13	8.11±0.16	5.10±0.09	4.97±0.06	3.51±0.04	3.48±0.03
9.	12.99±0.14	13.13±0.12	7.88±0.12	8.13±0.16	5.12±0.09	5.00±0.06	3.53±0.03	3.55±0.03
10.	13.12±0.16	13.02±0.16	7.85±0.28	8.14±0.20	5.27±0.13	4.88±0.15	3.44±0.07	3.46±0.03
11.	13.11±0.22	13.13±0.27	7.88±0.21	8.46±0.31	5.23±0.19	4.67±0.13	3.70+0.06	3.58±0.05
12.	13.23±0.16	13.06±0.06	8.20±0.14	7.96±0.08	5.03±0.05	5.10±0.06	3.68±0.04	3.62±0.06
13.	13.28±0.16	13.40±0.24	8.18±0.15	8.32±0.23	5.10±0.06	5.08±0.05	3.61±0.03	3.62±0.03

Table 81

Statistical analysis of fortnightly data on composition of milk
Total solids

A N O V A T A B L E (13th fortnight)

SOURCE	DF	SS	MSS	F
Treatment	1	041	041	.167NS
Error	10	2.428	.243	
Total	11	2.469		

SE of the difference between treatment 1 and 2 - .28452

CD at 5% level - .63390

CD at 1% level .90163

Table 82

Statistical analysis of fortnightly data on composition of milk -
Solids not fat

A N O V A T A B L E (13th fortnight)

SOURCE	DF	SS	MSS	F
Treatment	1	.054	.054	.238 NS
Error	10	2.257	.226	
Total	11	2.310		

SE of the difference between treatment 1 and 2 - 27426

CD at 5% level - .61105

CD at 1% level - .86913

NS - Not significant

Table 83
Statistical analysis of fortnightly data on composition of milk Fat
A N O V A T A B L E (13th fortnight)

SOURCE	DF	SS	MSS	F
Treatment	1	.001	.001	.045 NS
Error	10	.188	.019	
Total	11	.189		

SE of the difference between treatment 1 and 3 .07922

CD at 5% level - .17651

CD at 1% level = .25106

Table 84
Statistical analysis of fortnightly data on compositon of milk - Protein
A N O V A T A B L E (13th fortnight)

SOURCE	DF	SS	MSS	F
Treatment	1	.001	.001	.122 NS
Error	10	.054	.005	
Total	11	.054		

SE of the difference between treatment 1 and 2 .04236

CD at 5% level - .09438

CD at 1% level .13424

NS - Not significant

Table 85

Summarised data on fortnightly yield of butter fat

Group I		Group II		t values
Animal number	Average fortnightly butter fat yield (kg+SE)	Animal number	Average fortnightly butter fat yield(kg+SE)	I vs II
17.	4.86+0.11	23.	5.40+0.12	
18.	4.66+0.07	24.	4.54+0.09	
19.	4.43+0.20	25.	4.21+0.18	
20.	4.30+0.13	26	4.21+0.11	
21.	5.01+0 18	27	5.66+0.18	
22.	5.50+0.17	28	4.37+0.13	
Mean+SE	4.79+0.18		4.73+0.26	0.239 NS

NS - Not significant

Table 86

Summarised data on fortnightly yield of fat corrected milk (FCM)

Fortnights	Average fortnightly FCM yield(kg + SE)	
	Group I	Group II
1.	116 06+6.79	109.93-4.95
2.	119.26+6.61	112.77+3.63
3.	119.06+4.64	113.18+7.42
4	108.89+6.39	106.90+4.41
5.	116.33+4.34	118.91+6.01
6.	120.14+5.41	117.92+5.60
7.	113.69+3.89	113.38+6.40
8.	111.04+2.50	111.03+7.27
9.	99.78+1.68	106.17+5.40
10.	96.84+2.83	95.54+5.51
11.	96.57+6.80	99.23+8.47
12.	104 14+6.65	110.71+10.38
13.	104 82+7.67	107.32+11.93

Table 87

Statistical analysis of data on fortnightly yield of fat corrected milk (FCM)

A N O C O V A (13th fortnight)

SOURCE	DF	SXX	SXY	SYY
Treatments	1	112.80	-45.97	18.75
Error	10	2115.11	2545.36	6033.09
Total	11	2227.91	2499.39	6051.84
Treatment +Error	11	2227.91	2499.39	6051 84

Estimate of Reg. Coefficient (b cap) - 1.2034
Adj.Error - 2969.9643 with 9 df
Adj. (Treat. +Error) - 3247.8866 with 10 df
Adjusted Treat. - 277.9229 with 1 df
F = .8422 with 1 and 9 df (NS)

Table 88

Summarised data on fortnightly yield of total solids in milk

Group I		Group II		t-values
Animal number	Average fortnightly yield of total solids (kg+SE)	Animal number	Average fortnightly yield of total solids (kg+SE)	I vs II
17.	12.54+0.28	23	13.77+0.27	
18.	12.10+0.26	24.	12.33+0.27	
19.	11.87+0.58	25.	11.65+0.46	
20.	11.29+0.41	26.	11.18+0.29	
21.	13.22+0.43	27	15.47+0.29	
22.	14 51+0.44	28.	11.73+0.28	
Mean+SE	12.59+0.47		12.69+0 67	0.152 NS

NS Not significant

Table 89

Summarised data on fortnightly yield of solid corrected milk (SCM)

Group I		Group II		t values
Animal number	Average fortnightly SCM yield (kg±SE)	Animal number	Average fortnightly SCM yield (kg±SE)	I vs II
17.	103.57±2.24	23.	113.39±2.18	
18.	99.36±1.92	24.	99.94±2.09	
19.	96.56±4.55	25.	93.90±3.70	
20.	91.99±3.02	26.	90.89±2.27	
21.	107.95±3.50	27.	125.14±2.51	
22.	118.38±3.54	28.	95 31±2.44	
Mean±SE	102.97±3.82		103.10±5.47	0.024 NS

NS - Not significant

Table 90

Summarised data on efficiency of utilisation of dry matter

Fort nights	Average daily dry matter intake (g per $W_{kg}^{0.75}$ ±SE)		Average dry matter intake per kg FCM (kg±SE)	
	Group I	Group II	Group I	Group II
1.	158.13±8.17	157.58±9.86	1.27±0.06	1.41±0.07
2.	157.53±8.30	152.90±9.18	1.23±0.06	1.33±0.09
3.	148.48±7.63	145.68±9.07	1.16±0.04	1.28±0.12
4.	161.60+7.92	160.82±10.28	1.39±0.05	1.46±0.08
5.	161.38+7.45	159.83±10.10	1.30±0.03	1.36±0.09
6.	164.20+8.99	162.88±10.54	1.28±0.05	1.38±0 07
7.	162.88±9.50	162.43±10.48	1.35±0.05	1.44±0.07
8.	165.07±9.46	165.72±11.08	1.40±0.04	1.53±0.09
9.	161.87±8.35	158 77±12.04	1.53±0.05	1.52±0.08
10.	160.00+8.78	165.68±11 55	1.58±0.07	1.75±0 12
11.	162.40±8.66	163.83±11.74	1.65±0.14	1.68±0 08
12.	159.77+9.37	161.63±12.85	1.49±0.11	1.53±0 05
13.	159.75±8 33	159.23±12.37	1.50±0.12	1 52±0.08

Table 91
Statistical analysis of fortnightly data on average daily dry matter intake (g) per $W_{kg}^{0.75}$
A N O C O V A (13th fortnight)

SOURCE	DF	SXX	SXY	SYY
Treatments	1	97	.94	.84
Error	10	4917.75	5525.37	6676.28
Total	11	4918.72	5526 31	6677.13
Treatment + Error	11	4918.72	5526.31	6677 13

Estimate of Reg.Coefficient (b cap) 1.1236
Adj. Error 468.2046 with 9 df
Adj. (Treat.+ Error) 468.1645 with 10 df
Adjusted Treat -.0400 with 1 df
F 0008 with 1 and 9 df (NS)

Table 92
Statistical analysis of fortnightly data on average dry matter intake (kg) per kg FCM
A N O C O V A (13th fortnight)

SOURCE	DF	SXX	SXY	SYY
Treatments	1	.06	.01	.00
Error	10	.25	.29	65
Total	11	31	30	.65
Treatment+Error	11	.31	.30	65

Estimate of Reg.Coefficient (b cap) 1.1597
Adj.Error - 3175 with 9 df
Adj.(Treat. + Error) - .3730 with 10 df.
Adjusted Treat - .0555 with 1 df
F 1 5723 with 1 and 9 df
NS Not significant

Table 93
Summarised data on fortnightly intake of gross energy

Group I		Group II		t value
Animal number	Average fortnightly intake of gross energy (M cal±SE)	Animal number	Average fortnightly intake of gross energy (M cal±SE)	I vs II
17.	643.52±8.44	23.	647 65±13.19	
18.	524.09±4.98	24.	606.24+9.68	
19.	648.21+7.41	25.	518.40±5.65	
20.	583.93±5.63	26.	646 90±9.61	
21.	672.23±8.02	27.	743 83±8.34	
22	658.75±6.89	28	626.51±9.14	
Mean±SE	621.79±23 14		631 59±29 76	0.309 NS

Table 94
Summarised data on average daily intake of gross energy (k cal) per $W_{kg}^{0.75}$

Group I		Group II		t value
Animal number	Average daily intake of gross energy (kcal±SE)	Animal number	Average daily intake of gross energy (kcal±SE)	I vs II
17.	693 02±8.30	23.	684 79±9.83	
18.	511 92±4 30	24	755 24+9 03	
19.	732.94±6.47	25.	463 91±5.80	
20	618.49±4 55	26	644.25±8.37	
21.	677.62±6.39	27	760 88±7.50	
22	736.56±8.21	28	632 38±20.17	
Mean±SE	661.76±34.74		656.91±44.45	0 072 NS

NS Not significant

Table 95
Summarised data on average gross energy intake (M cal) per kg FCM

Group I		Group II		t value
Animal number	Average gross energy intake per kg FCM±SE	Animal number	Average gross energy intake per kg FCM±SE	I vs II
17.	5.87±0.15	23.	5.28±0.16	
18.	4.95±0.11	24.	5.77±0.17	
19.	6.51±0.35	25.	5.35±0.24	
20.	6.02±0.22	26.	6.89±0.32	
21.	5.94±0 22	27.	5.66±0.14	
22.	5.28±0.21	28.	6.27±0.23	
Mean±SE	5.76±0.23		5.87±0.25	0 310 NS

Table 96
Summarised data on efficiency of conversion of gross energy into milk energy

Group I		Group II		t-value
Animal number	Average percent of gross energy converted into milk energy±SE	Animal number	Average percent of gross energy converted into milk energy ±SE	I vs II
17.	12.89±0.34	23.	14.39±0.48	
18.	15.46±0.39	24	13.13±0.38	
19.	11.91±0.61	25.	14.32±0.60	
20.	12.62±0.41	26.	11.13±0.45	
21.	12 84±0.46	27.	13 34±0.31	
22.	14.47±0 54	28	12.13±0.37	
Mean±SE	13.37±0.54		13.07±0.52	0.365 NS

NS - Not significant

Table 97
Summarised data on fortnightly intake of TDN

Group I		Group II		t value
Animal number	Average fortnightly in take of TDN(kg+SE)	Animal number	Average fortnightly in-take of TDN (kg+SE)	I vs II
17.	82.73+1.71	23.	85.50+1.78	
18.	69.86+0.62	24.	79.66+1 27	
19.	86.59+0.71	25.	68.13+0.75	
20.	77.70+0.75	26.	85.05+1.26	
21	89.47+1.07	27.	97.74+1 10	
22	87.36+0.86	28.	82.33+1 20	
Mean+SE	82.29+3.01		83.07+3 92	0.186 NS

Table 98
Summarised data on intake of TDN (kg) per kg FCM
including maintenance

Group I		Group II		t value
Animal number	Average TDN intake (kg) per kg FCM+SE	Animal number	Average TDN intake (kg) per kg FCM+SE	I vs II
17.	0.75+0.00	23.	0.70+0.02	
18.	0.66+0 01	24.	0.76+0.02	
19.	0.87+0.04	25.	0.70+0.03	
20.	0.80+0.03	26.	0.91+0.04	
21.	0.79+0.03	27.	0.74+0.02	
22.	0.70+0.03	28.	0.82+0.03	
Mean+SE	0.76+0.03		0 77+0.03	0.231 NS

NS Not significant

Table 99

Summarised data on fortnightly intake of digestible energy

Group I		Group II		t value
Animal number	Average fortnightly intake of digestible energy (M cal ±SE)	Animal number	Average fortnightly intake of digestible energy (M cal±SE)	I vs II
17.	356.52±4.68	23.	361.45±7.36	
18.	290.34±2.76	24.	338.33±5.41	
19.	359.12±4.10	25.	285.32±3.16	
20.	323.49±3.12	26.	361.12±5.32	
21.	372.41±4.45	27.	415.13±4.66	
22.	364.95±3.81	28.	349.58±5.07	
Mean±SE	344.47±12.82		351.82±17.12	0 451 NS

Table 100

Summarised data on average daily intake of digestible energy per $W^{0\ 75}_{kg}$

Group I		Group II		t-value
Animal number	Average daily intake of digestible energy (K cal) per $W^{0.75}_{kg}$ ±SE	Animal number	Average daily intake of digestible energy (K cal) per $W^{0.75}_{kg}$ ±SE	I vs II
17.	383.93±4.60	23.	382.17±5.49	
18.	283.63±2.39	24	421.50±5.04	
19.	406.05±3 58	25.	258.92±3.24	
20.	342.66±2.53	26.	359.55±4.68	
21.	375.40±3.54	27.	424.64±4.19	
22.	408.40±4.29	28.	361.82±4.15	
Mean±SE	366.68±19.27		368.10±24.68	0.038 NS

NS - Not significant

Table 101

Summarised data on intake of digestible energy (M cal) per kg FCM (including maintenance)

Group I		Group II		t value
Animal number	Average digestible energy intake (M cal) per kg FCM±SE	Animal number	Average digestible energy intake (M cal) per kg FCM±SE	I vs II
17.	3.09±0.17	23.	2.94±0.09	
18.	2.74±0.06	24.	3.22±0.09	
19.	3.61±0.19	25.	2.99±0.13	
20.	3.34±0.12	26.	3.85±0.18	
21.	3.29±0.12	27.	3.16±0.08	
22	2.92±0.11	28.	3.49±0.13	
Mean±SE	3.17±0.13		3.28±0.14	0.585 NS

Table 102

Summarised data on efficiency of conversion of digestible energy into milk energy

Group I		Group II		t value
Animal number	Average percent of digestible energy converted into milk energy ±SE	Animal number	Average percent of digestible energy converted into milk energy±SE	I vs II
17.	23.11±0.60	23.	25.78±0.86	
18.	27.49±0.62	24.	23.53±0.68	
19.	21.50±1 11	25.	25.50±1 08	
20.	22.79±0.74	26.	19.94±0.80	
21.	23.16±0.83	27.	23.90±0.55	
22.	26.12±0.97	28.	21.73±0.66	
Mean±SE	24.03±0.93		23.40±0.91	0.448 NS

NS Not significant

Table 103
Summarised data on fortnightly intake of crude protein

Fort nights	Average fortnightly intake of crude protein (kg±SE)		Average daily intake of crude protein(g) per $W^{0.75}_{kg}$ ±SE		Average crude protein intake (kg) per kg FCM±SE	
	Group I	Group II	Group I	Group II	Group I	Group II
1.	18.36±0.80	18.54±0.83	19.98±1.16	19.93±1.28	0.160±0.008	0.178±0.009
2.	17.94±0.78	17.84±0.81	19.50±1.15	19.07±1.20	0.151±0.007	0.166±0.010
3	18.06±0 74	18 30±0 84	19.57±1.09	19.45±1.25	0.152±0.006	0.171±0.150
4.	19.75±0.77	20.11±0.85	21.28±1.11	21.30±1.38	0.183±0.008	0.192±0.010
5.	18.46±0.69	18.76±0.82	19.80±1.02	19.77±1.28	0.159±0.005	0.168±0.011
6.	18.46±0.78	18.82±0.87	19.77±1.13	19.75±1.29	0.154±0.006	0.166±0.008
7.	18.90±0.85	19.32±0.89	20.12±1.19	20.17±1.33	0.166±0.006	0.179±0.009
8.	18.78±0.83	19.21±0.99	19.92±1.16	19.97±1.41	0.169±0.005	0.184±0.011
9.	18.37±0.73	18.65±0.96	19.45±1.05	19.33±1.45	0.184±0.007	0.185±0.010
10.	17.63±0.74	18.93±1.02	18.53±1.03	19.53±1.47	0 183±0.010	0.206±0 014
11.	18.49±0.77	19 17±0.99	19.37±1.05	19 70±1.45	0.197±0.017	0 202±0.010
12.	17.79±0.70	18.60±1.24	18.63±1.05	19.08±1.69	0.174±0.013	0.180±0.006
13.	18.47±0.64	18.74±1.23	19.20±1.00	19.12±1.67	0.181±0.015	0.181±0.009

Table 104
Statistical analysis of fortnightly data on crude protein intake
A N O C O V A (13th fortnight)

SOURCE	DF	SXX	SXY	SYY
Treatments	1	10	15	22
Error	10	40 10	41.69	57 72
Total	11	40 20	41.83	57 94
Treatment+Error	11	40 20	41 83	57.94

Estimate of Reg Coefficient (b cap) 1.0396
Adj.Error - 14.3780 with 9 df
Adj. (Treat. + Error) 14.4004 with 10 df
Adjusted Treat. 0223 with 1 df
F .0140 with 1 df and 9 df NS

Table 105
Statistical analysis of fortnightly data on average daily intake of crude protein (g) per $W_{kg}^{0.75}$

A N O C O V A (13th fortnight)

SOURCE	DF	SXX	SXY	SYY
Treatments	1	01	.01	.02
Error	10	89 00	94.04	113.15
Total	11	89.01	94.05	113.17
Treatment + Error	11	89 01	94.05	113.17

Estimate of Reg Coefficient (b cap) 1.0566
Adj. Error 13 7929 with 9 df
Adj (Treat. + Error) - 13.7948 with 10 df
Adjusted Treat. .0019 with 1 df
F - .0012 with 1 and 9 df (NS)

NS Not significant

Table 106

Statistical analysis of data on average crude protein intake (kg) per kg FCM

A N O C O V A (13th fortnight)

SOURCE	DF	SXX	SXY	SYY
Treatments	1	.00	.00	.00
Error	10	.00	.00	.01
Total	11	.01	.00	.01
Treatment + Error	11	.01	.00	.01

Estimate of Reg. Coefficient (b cap) - 1.1433
Adj. Error = .0032 with 9 df
Adj. (Treat. + Error) .0043 with 10 df
Adjusted Treat. = .0010 with 1 df
F = 2.9117 with 1 and 9 df (NS)

Table 107

Summarised data on fortnightly intake of digestible crude protein (kg)

Group I		Group II		t value I vs II
Animal number	Average fortnightly intake of DCP (kg±SE)	Animal number	Average fortnightly intake of DCP (kg±SE)	
17.	11.32±0.12	23.	11.75±0.14	
18.	8.81±0.38	24.	10.97±0.12	
19.	11.76±0.10	25.	9.06±0 16	
20.	10.76±0.09	26.	11.62±0.13	
21.	12.25±0.12	27.	13.29±0.09	
22.	11.82±0.14	28.	11.22±0.10	
Mean±SE	11.12+0.51		11.32±0.56	0.300 NS

NS - Not significant

Table 108

Summarised data on average daily intake of digestible crude protein (g) per $W_{kg}^{0.75}$

Group I		Group II		t value I vs II
Animal number	Average daily intake of DCP (g) per $W_{kg}^{0.75}$ ±SE	Animal number	Average daily intake of DCP(g) per $W_{kg}^{0.75}$ ±SE	
17	12.21±0 12	23	12 44±0 09	
18.	8.99±0 10	24.	13 66±0 13	
19.	13 30±0.16	25.	8.12±0.18	
20.	11.40±0.14	26	11.57±0.16	
21.	12 35±0 14	27	13.58±0.09	
22.	13.23±0.15	28.	11.62±0 09	
Mean±SE	11.91±0.65		11.83±0.83	0 064 NS

Table 109

Summarised data on average DCP intake (g) per kg FCM

Group I		Group II		t value I vs II
Animal number	Average intake of DCP (g) per kg FCM±SE	Animal number	Average intake of DCP (g) per kg FCM±SE	
17.	103 13±2.28	23.	95.64±2 15	
18.	86.89±1.82	24	104.33±2.45	
19	117 55±5 33	25	93.12±3.48	
20.	111.01±3.46	26.	123.42±4.74	
21	107.88±3.04	27	101 21±2.62	
22.	94.21±2 58	28.	112.16±3.58	
Mean±SE	103.45±4.60		104.98±4 60	0.231 NS

NS - Not significant

Table 110

Summarised data on nitrogen balance and efficiency of nitrogen utilisation

	Group I	Group II	t-value I vs II
Number of animals	6	6	
Average total nitrogen intake (g/day)	211.480±8.98	216.693±11.27	
Average nitrogen excretion in dung (g/day)	83.987±3.54	86.528±6.14	
Average nitrogen excretion in urine (g/day)	89.353±6.57	87.280±5.60	
Average nitrogen in milk (g/day)	34.125±2.73	37.658±3.37	
Average nitrogen balance (g/day) in tissues	4.02±1.08	5.23±0.79	0.799 NS
Average nitrogen retained (tissue+milk) as % of total intake	18.19±1.21	19.77±0.86	1.253 NS
Average nitrogen retained (tissue+milk) as % of absorbed	30.35±2.38	32.98±1.33	0.907 NS
Average nitrogen in milk as percent of absorbed	27.16±2.68	28.86±1.59	0.579 NS
Average nitrogen retained in tissue as percent of intake	1.57±0.40	2.44±0.36	1.325 NS

NS - Not significant

Table 111
Summarised data on fortnightly feed cost (Rs)

Group I		Group II		t value
Animal number	Average fortnightly feed cost (Rs ±SE)	Animal number	Average fortnightly feed cost (Rs±SE)	I vs II
17.	242.93±2.03	23	254.22±1 58	
18.	197.41±2.46	24.	237.42±1 70	
19.	252 06±2 96	25.	196.45±4 40	
20.	230.82±2.85	26	251.51±3 16	
21.	262.36±2.59	27	287.94_2 31	
22.	253.32±4.61	28.	243.36±1 20	
Mean±SE	239.82±9 54		245.15±12.09	0.399 NS

Table 112
Summarised data on fortnightly value of milk produced (Rs)

Group I		Group II		t value
Animal number	Average fortnightly value of milk (Rs±SE)	Animal number	Average fortnightly value of milk (Rs±SE)	I vs II
17	551 56±11.28	23	617 26±11 79	
18.	530.91±8 04	24	528 24±10 08	
19	512.47±23.05	25	494.62+20.53	
20.	490.54±14.02	26	477 64±15 73	
21.	573.36±16.99	27	661.13+16 26	
22.	633.57±20.10	28.	504.91±13.26	
Mean±SE	548 74±20.68		547 30±30 35	0.039 NS

NS Not significant

Table 113
Summarised data on fortnightly income over feed cost (Rs)

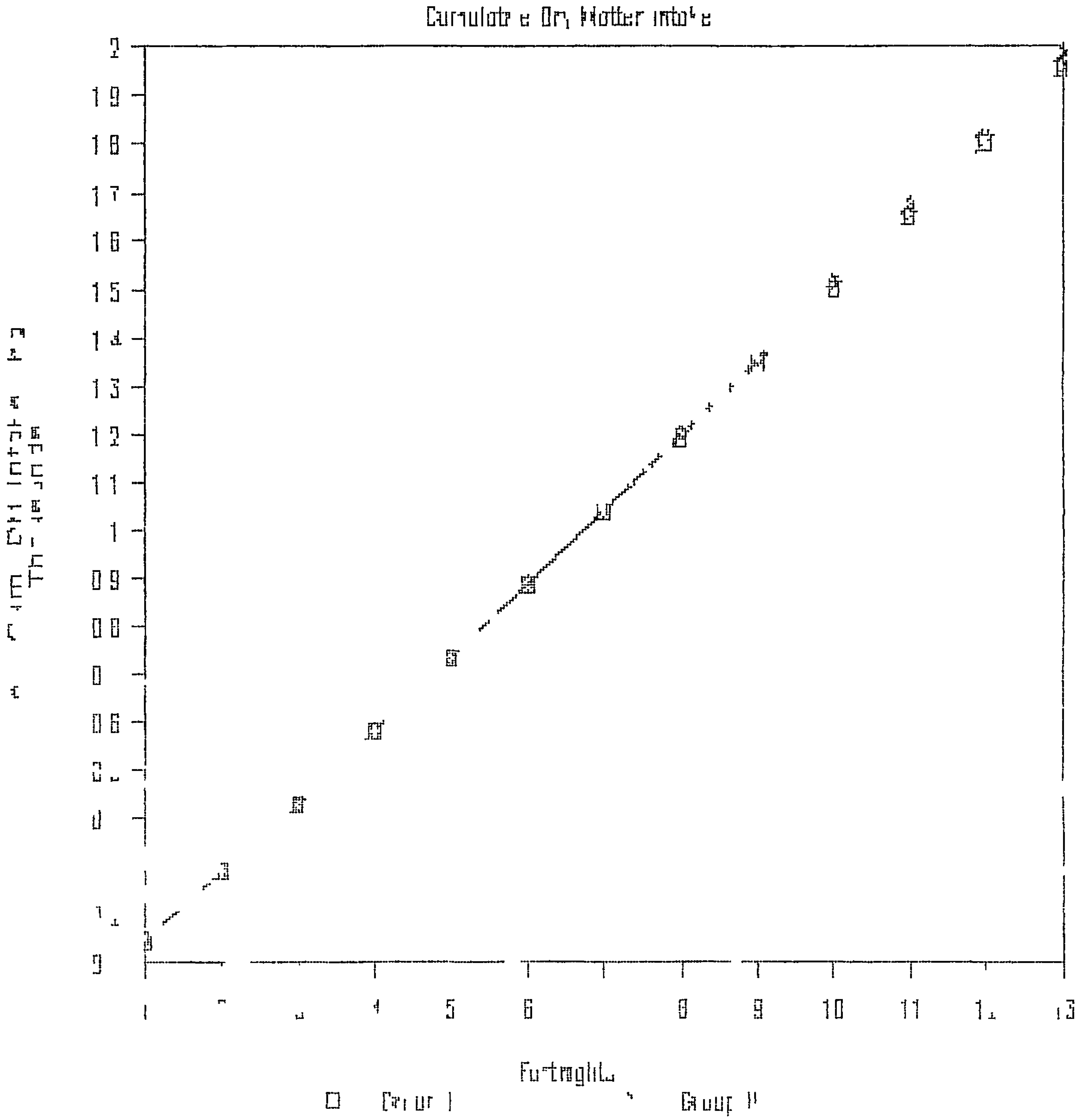
Group I		Group II		t-value
Animal number	Average fortnightly income over feed cost (Rs+SE)	Animal number	Average fortnightly income over feed cost(Rs+SE)	I vs II
17.	308.63+1042	23.	363.04+12 67	
18.	333.50+7 83	24.	290 82+10 19	
19.	260.40+21.54	25.	298.17+17.13	
20.	259.73+12.83	26.	226 13+14 89	
21.	311.00+15.01	27	373.19+16.52	
22.	380.25+16.69	28.	261.56+13.61	
Mean+SE	308.92+18.68		302 15+23 33	0 226 NS

Table 114
Summarised data on dairy merit

Group I		Group II		t-value
Animal number	Average dairy merit (%) +SE	Animal number	Average dairy merit (%) +SE	I vs II
17.	22.01+0.58	23.	24.78+0.85	
18.	25.95+0.56	24.	22.71+0.66	
19.	20.23+0.99	25.	24.76+1.04	
20.	21.57+0.71	26.	19.25+0.77	
21.	21.92+0.79	27.	23.07+0.53	
22.	24.78+0.89	28.	20.97+0.64	
Mean+SE	22.74+0.88		22.59+0.89	0.114 NS

NS Not significant

Fig 11



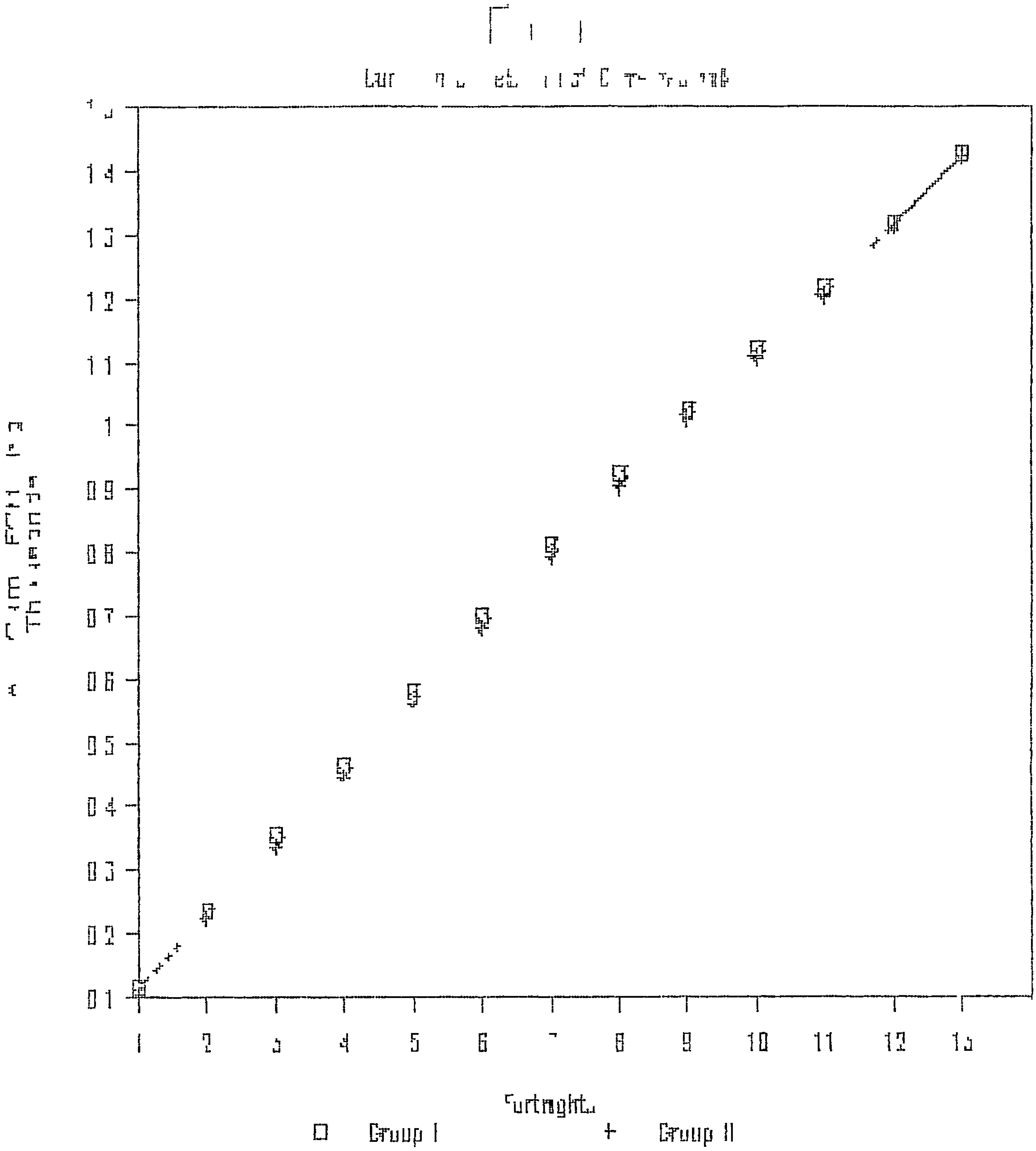

1 4
1 3
1 2
1 1
1
0 9
0 8
0 7
0 6
0 5
0 4
0 3
0 2
0 1
1
2
4
5
6
8
9
10
11
Group I
Group II

Fig 17

Cum yield of Solids Corrected Milk

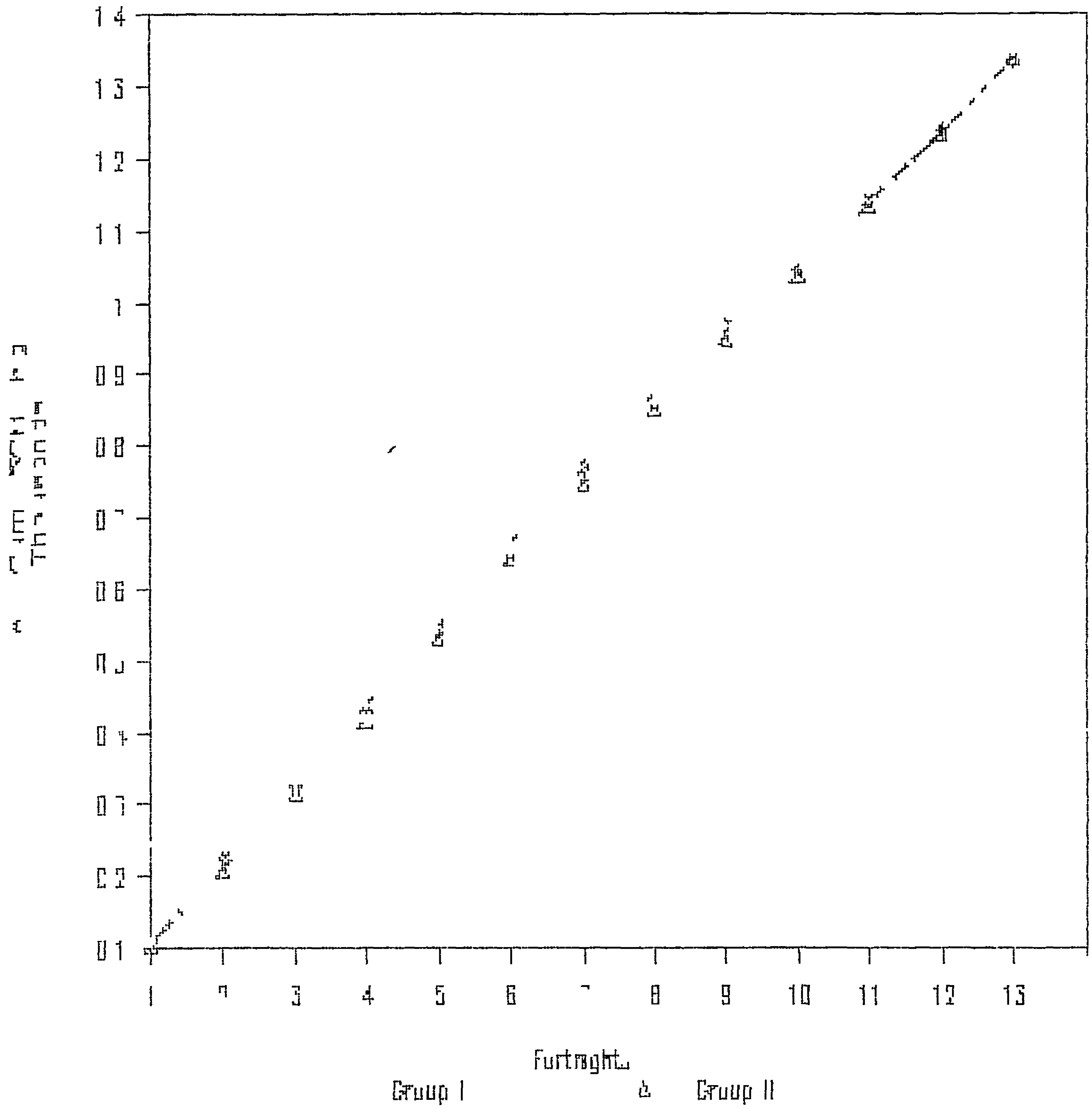


Fig 14

Cumulative Gross Energy intake

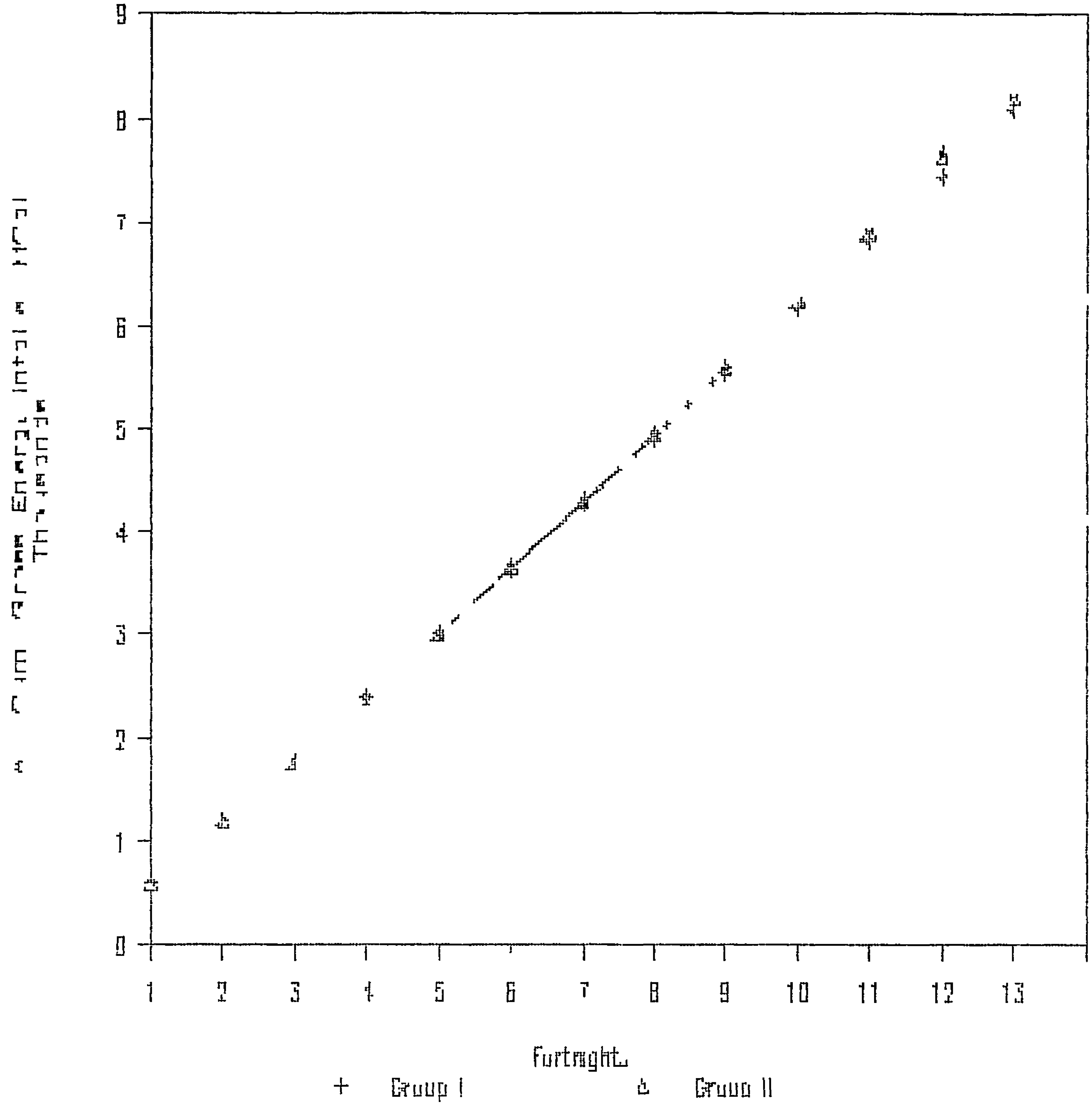
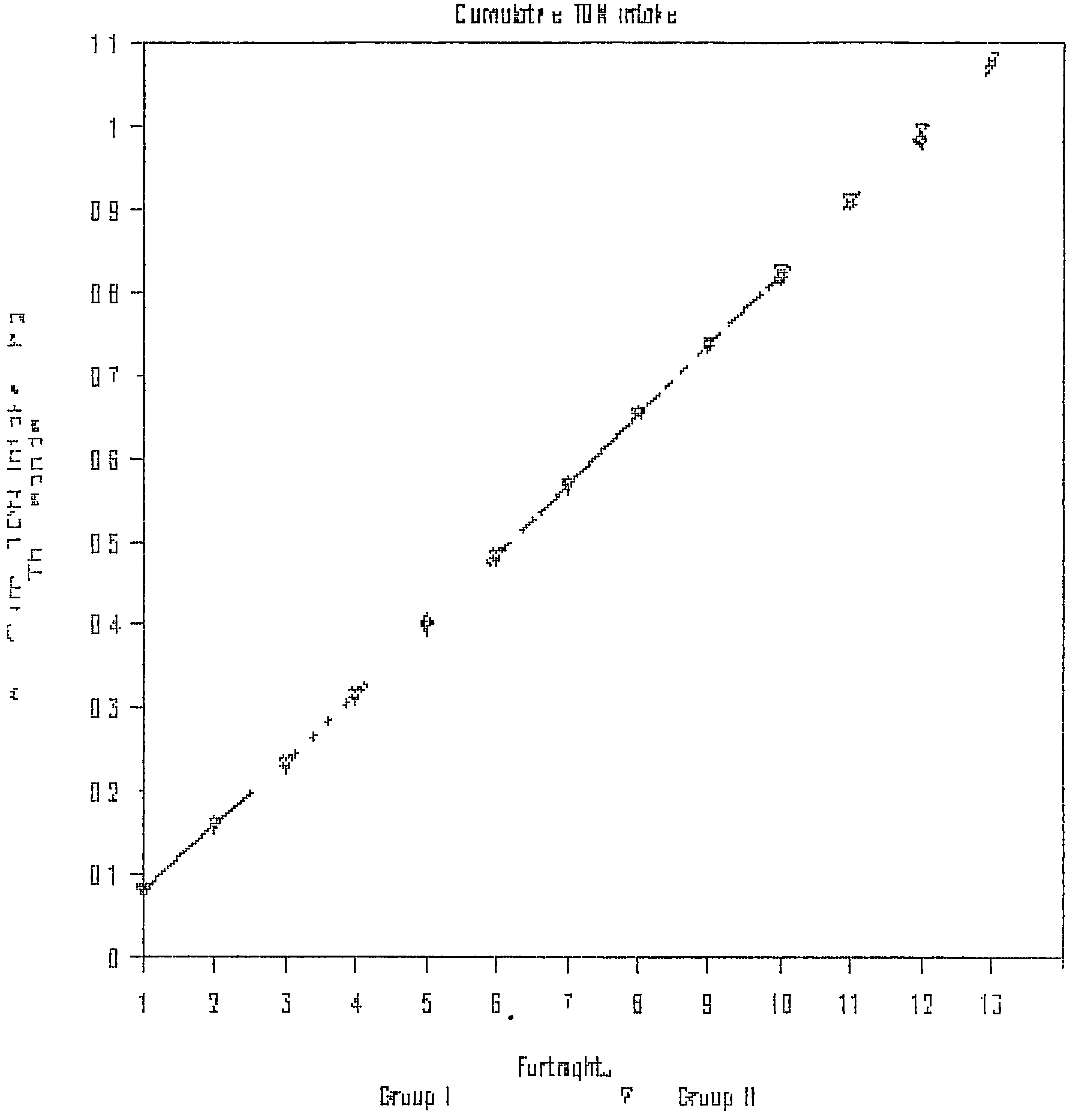


Fig 15



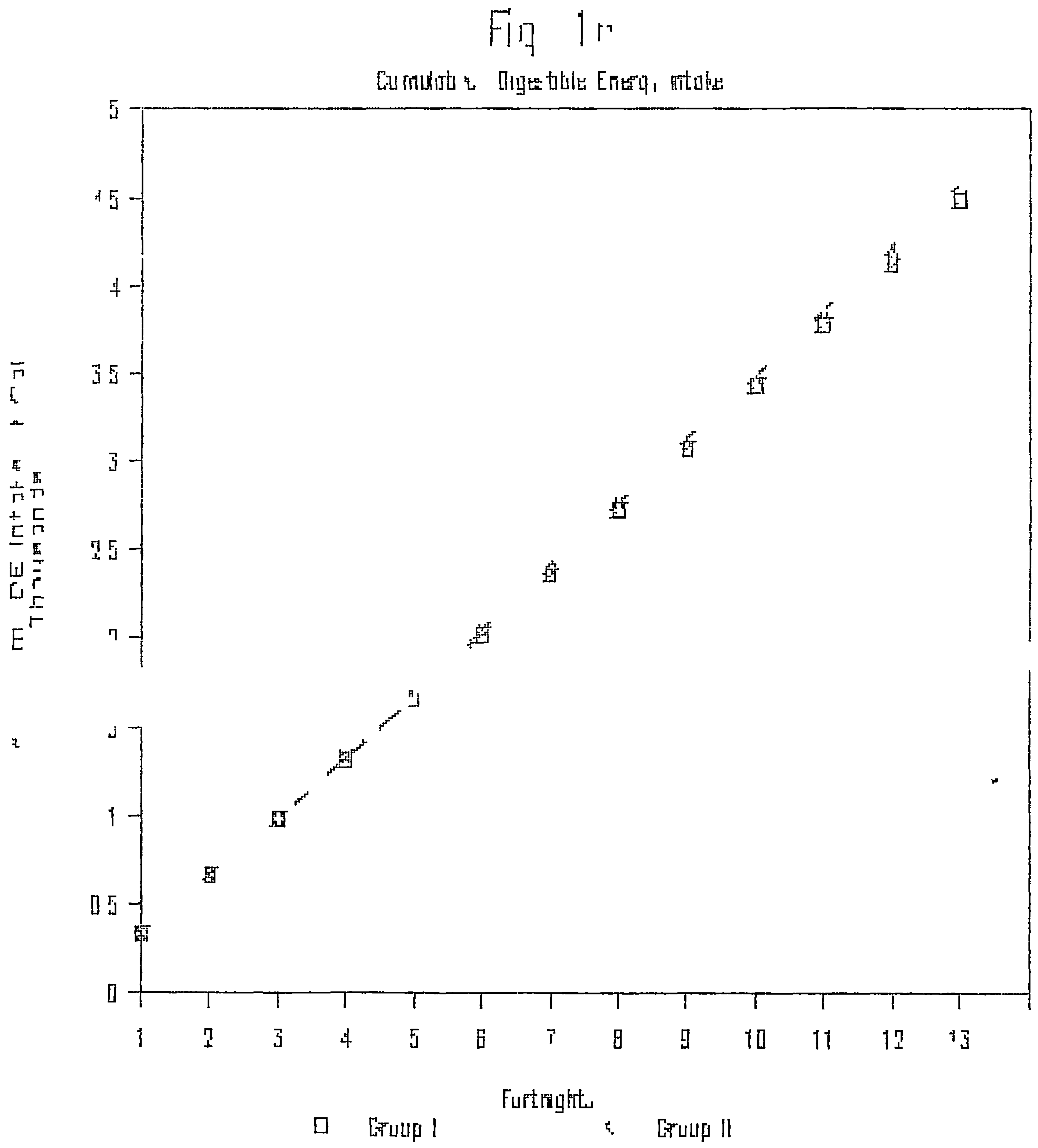


Fig 1r
Cumulative Digestible Energy intake
5
4.5
4
3.5
3
2.5
2
1
0.5
0
1
2
3
4
5
6
7
8
9
10
11
12
13
Fortnight
Group I
Group II

Fig 17

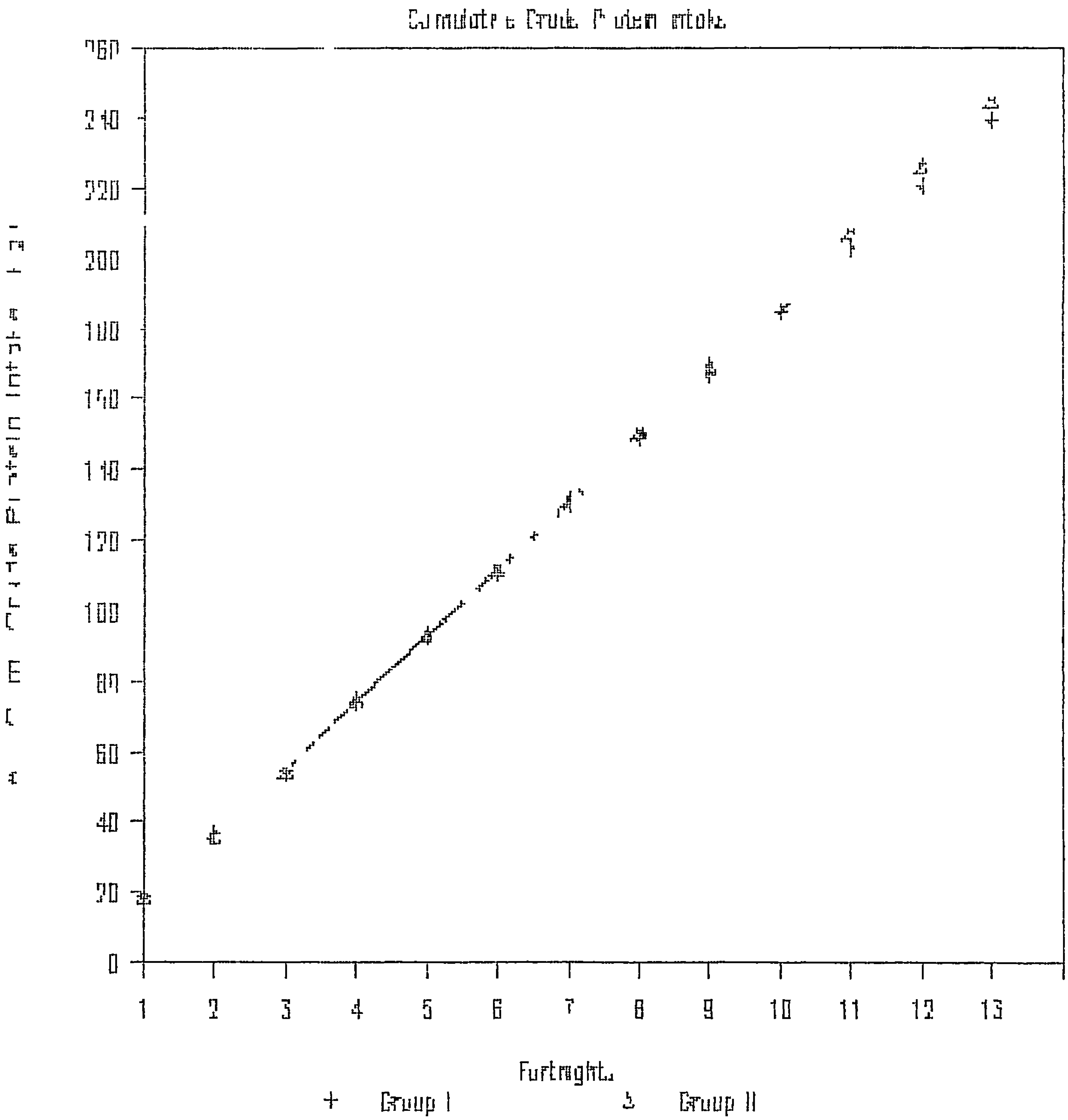
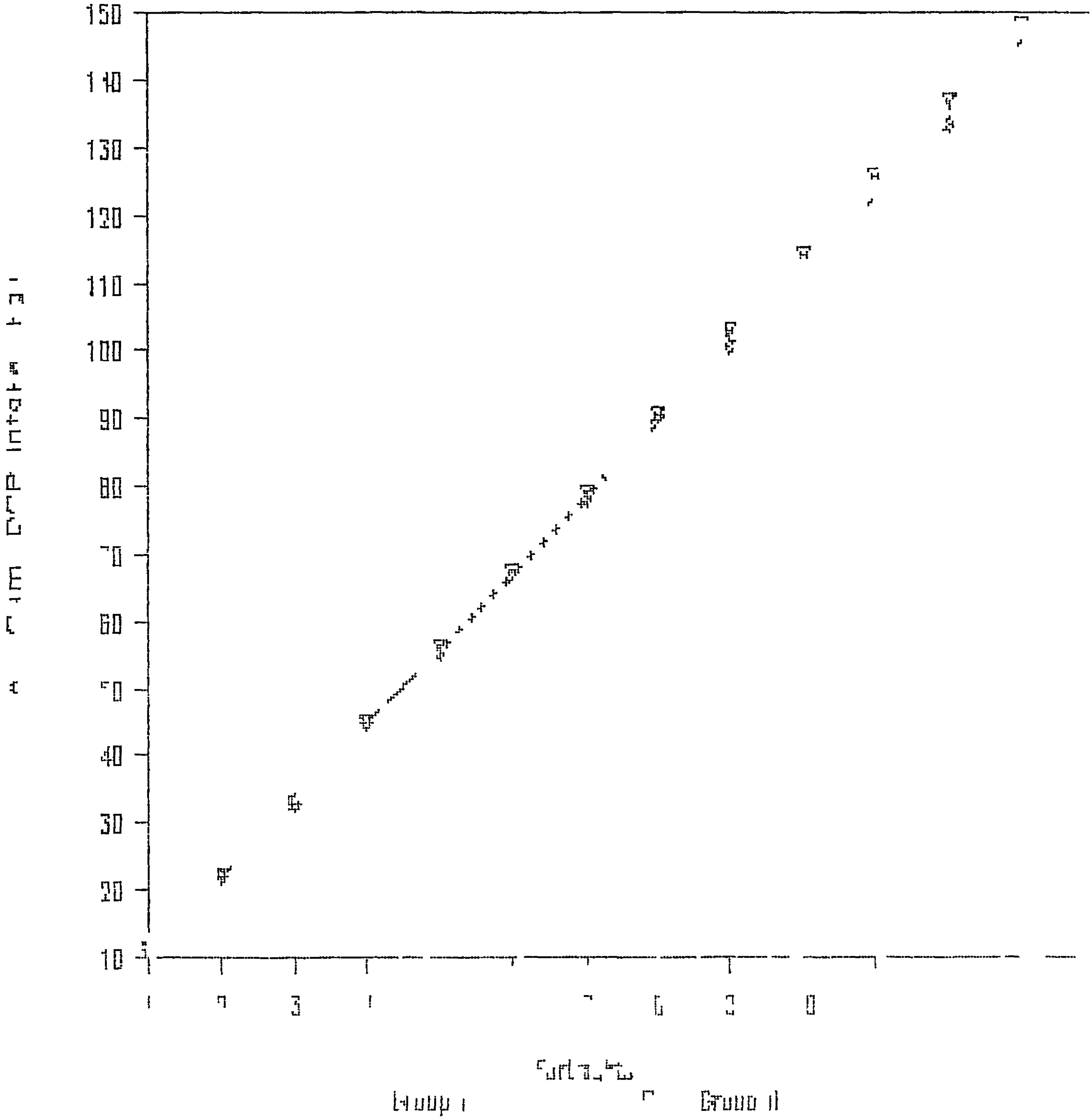

Fortnights
+ Group I
Group II
1
2
3
4
5
6
7
8
9
10
11
12
13
0
20
40
60
80
100
120
140
160
200
220
240

Fig 1[illegible]

Cumulative DCP intake



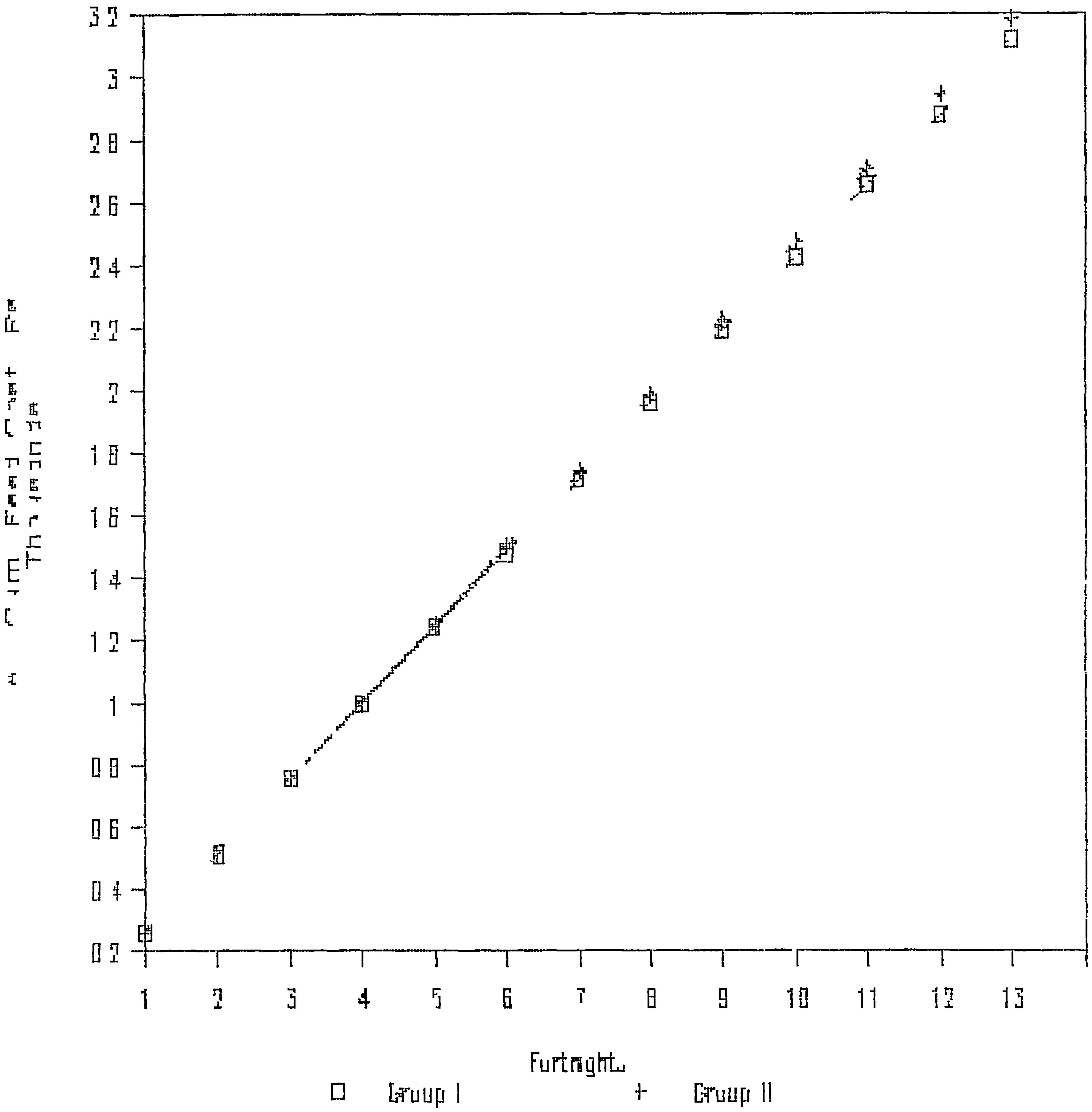


Fig 14

Cumulative Feed Cost

Fig 10

Cumulative Milk value [Rs]

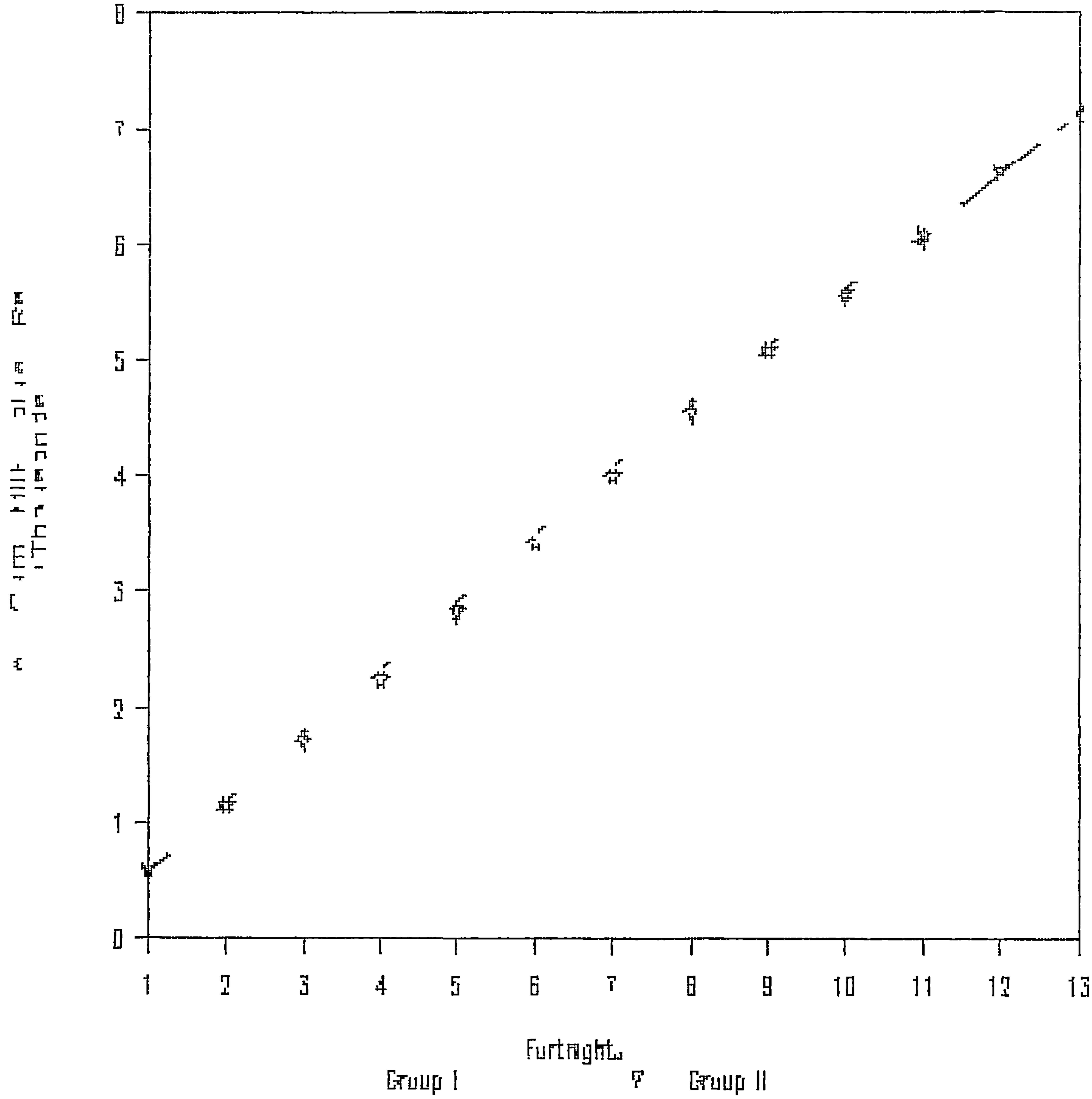
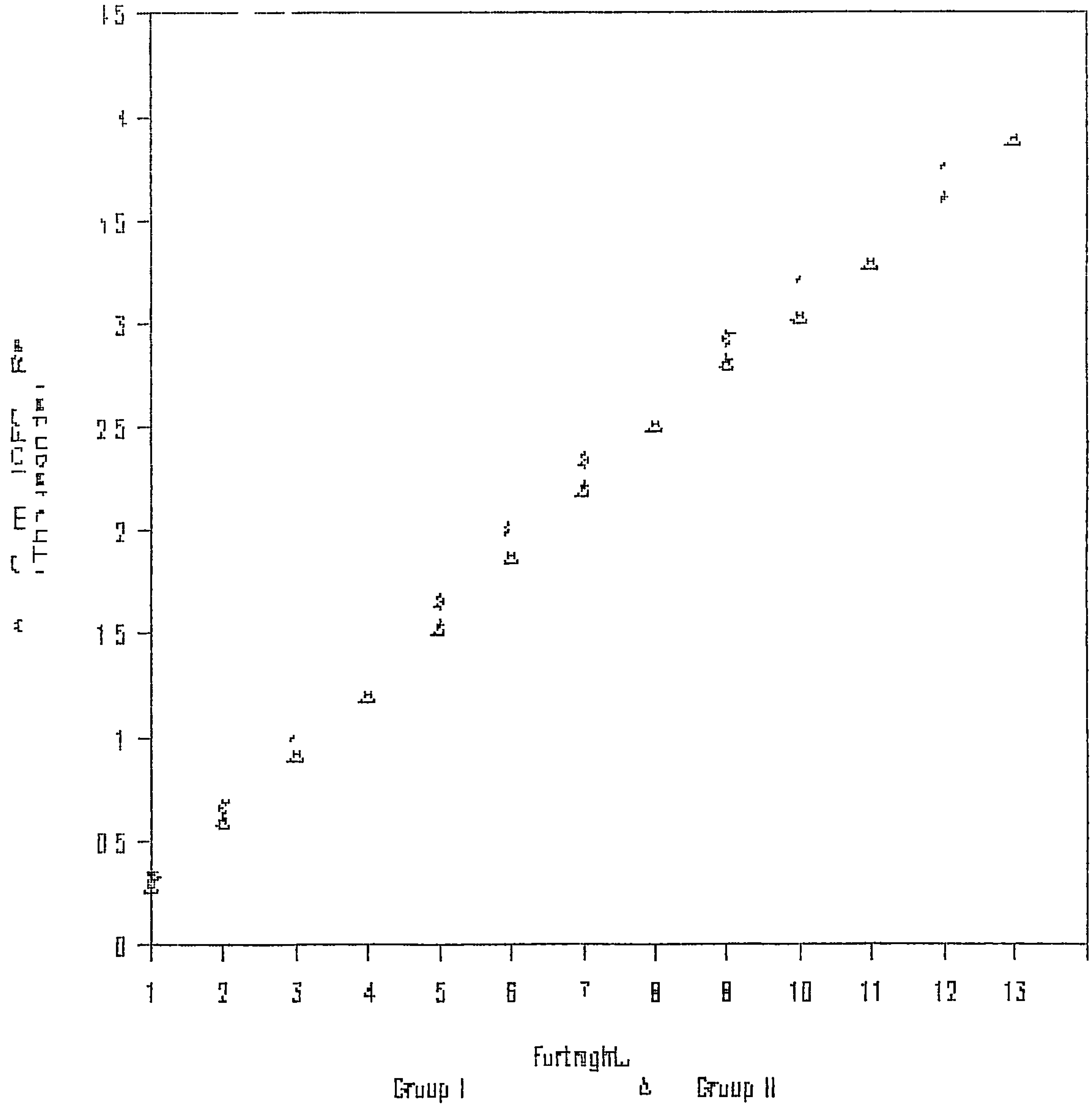
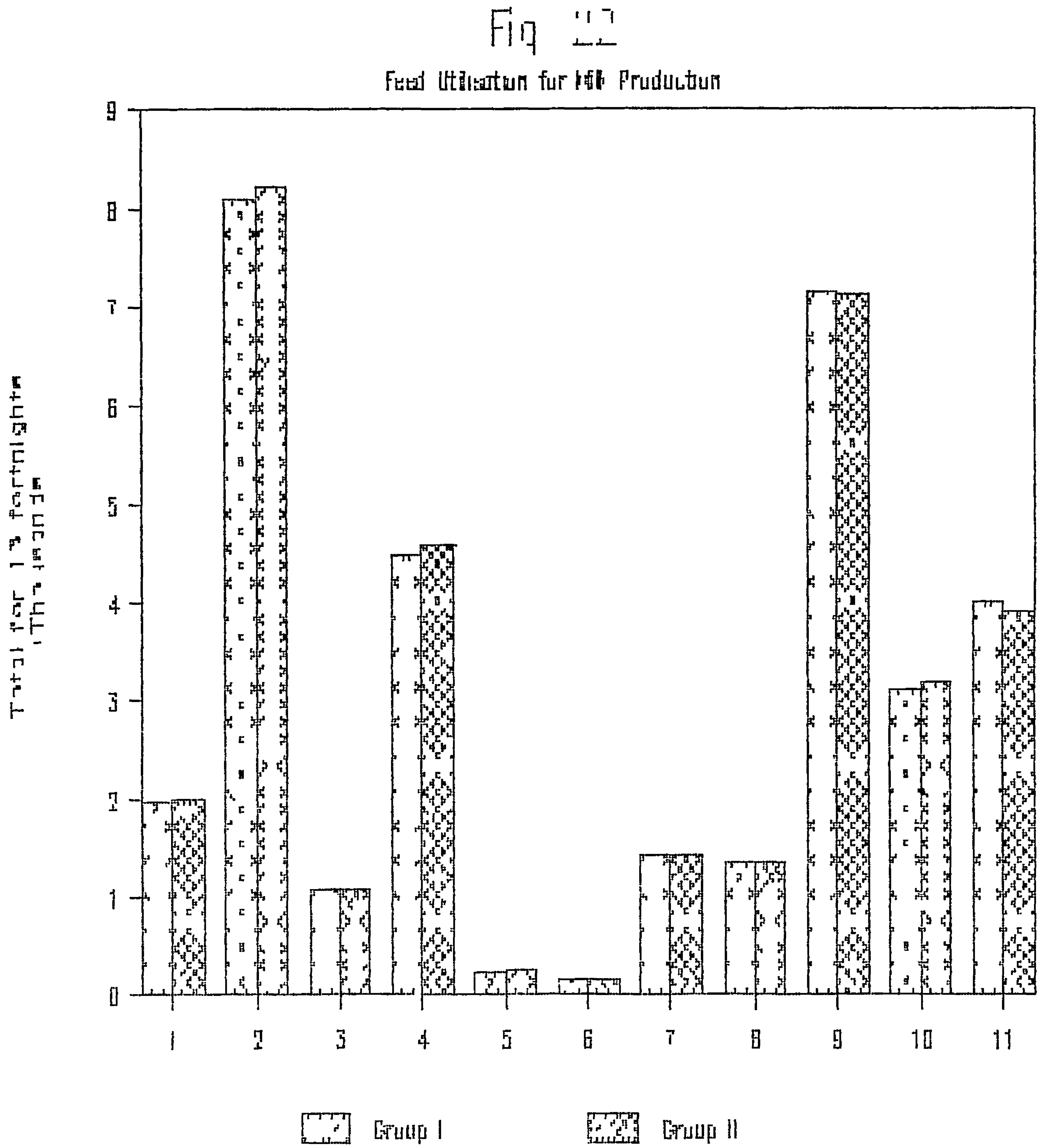


Fig 21


Cumulative Income Over Feed Cost [IOFC]
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
1
2
3
4
5
6
7
8
9
10
11
12
13
Fortnight
Group I
Group II



1. DM intake (kg)
2. Gross energy intake (Mcal)
3. TDN intake (kg)
4. Digestible energy intake (Mcal)
5. Crude protein intake (kg)
6. DCP intake (kg)
7. F.C.M. yield (kg)
8. S.C.M. yield (kg)
9. Milk value (Rs)
10. Feed cost (Rs)
11. Income over feed cost (Rs)

DISCUSSION

5. DISCUSSION

The results obtained on growth and lactation studies are discussed separately under Part I and II respectively

Part I

5.1. Growth study

5.1.1. Body weight.

It can be seen from Table 5 and Fig.1 that while crossbred Jersey calves weighed on an average 64.75±6.61, 137.00±7.51 and 204.50±9.10 kg respectively at the beginning, middle and end of the experimental period of 28 fortnights, crossbred Brown Swiss calves weighed on an average 74.19±6.46, 142.31±8.47 and 203.75+11.40 kg respectively during the same period. The analyses of covariance of data for all the 28 fortnights by taking initial body weight as the concomitant variable show that there is no statistically significant difference between the two crossbred groups in this regard, except in respect of the first fortnight. The analysis of covariance of data for first, 14th and 28th fortnights are detailed in Tables 6-8.

The data on average fortnightly weight gain and the statistical analysis of the same given in Table 9 and Figs. 2 and 10 indicate that there is no significant difference between the two genetic groups in regard to the weight gain, the average daily weight gain during the entire period of 28 fortnights being 356.6 and 329.9 g for crossbred Jersey and crossbred Brown Swiss heifer calves respectively.

The results obtained are essentially in accordance with the observations of Bhat and Singh (1978) who reported that from 12 24 months of age, Hariana x Jersey crossbred animals gained 391.7 g per day compared to 368.7 g per day in the case of Hariana x Brown Swiss crosses and that no significant difference was found between the two genetic groups with average body weights of 310.00±11.96 and 301.47+7.98 kg respectively at 24 months of age. Singh and Bhat (1979) from their studies on different crossbreds (Hariana x Holstein Friesian, Hariana x Brown Swiss; Hariana x Jersey) reported that there was no significant difference between them in respect of their growth performance. Bhatnagar et al. (1975), however, reported an average daily weight gain of 250 g per day in Sahiwal x Brown Swiss crosses during 9-12 months of age as against 329.9 g per day for Brown Swiss crosses in the present study. Sreenivasa Mohan et al. (1987), however, reported higher average weight gain of 464.00+19.08 g per day in Jersey x Ongole crossbred heifers weighing initially on an average, 88.20±12.23 kg when fed according to N.R.C. standard over an experimental period of 100 days. Srivastav et al. (1985) reported that Brown Swiss crosses were significantly superior to Jersey crosses upto four months and from 15 months onwards, in respect of average daily gain. They, however, observed that there were no significant differences between Brown Swiss and Jersey crosses in respect of their body weights from 5 14 months of age.

Hollon et al. (1972) and Bhat and Singh (1978) reported significantly higher growth rate in Holstein crosses than in Jersey and Brown Swiss crosses with Zebu. They observed maximum growth rate during the 7th and 9th month in postweaning period in the case of Jersey and Holstein crosses respectively. Branton et al. (1961), Patel (1978) and Rao and Nagarcenkar (1979), however, reported maximum growth rate between third and sixth month of age while Singh (1974) and Parekh et al. (1976) reported maximum growth rate between 6th and 12th month of age in different crossbred calves. The consensus of opinion seems to be that the crossbreds with various levels of Brown Swiss and Holstein Friesian inheritance show maximum growth rate during fourth and sixth month of age (McDowell et al., 1959; Branton et al., 1961; Mudgal and Ray, 1965; Parija, 1972 and Hingane, 1975). Chawla and Mishra (1981) studied in detail the role of Brown Swiss and Holstein-Friesian genes on growth rate using data on 689 Sahiwal, 639 Brown Swiss x Sahiwal and 3802 Holstein Friesian x Sahiwal crossbreds and found that body weights at various intervals of age had curvi-linear relationship with the increase of Holstein-Friesian inheritance from 1/8 to 7/8, except at birth and at 2 months of age when it was linear. Superiority of body weight gain by Brown Swiss gene infusion over Sahiwal females measured in percentage was 16.9 (F2 and F3) to 28.5 (1/2 F1) at 12 months of age and 12.2 (F2 and F3) to 17.6 (3/4) at first calving. Corresponding values for Holstein-Friesian grades were 15.1 (1/8) to 25.7 (4/8) and 3.3 (1/8) to 8.7 (4/8) respectively. They found that cross breds with various levels of Brown Swiss and Holstein-Friesian inheritance showed maximum growth rate (g/day) during 4-6 months of age, followed by steep fall in growth rate during 6-9 months which further declined in between 15 and 18 months of age. Patel et al.(1985) found that Holstein crossbred calves were heavier at birth and that they remained consistently heavier than the Jersey crosses upto one year of age.

The variations in respect of body weight as well as weight gain of crossbreds in different reports available in the literature, can, however, be attributed to the differences in the genetic potentials of various native foundation stock originally used for the different breeding programmes. According to Vij and Basu (1986), the progeny of Tharparkar dams were superior to that of Sahiwal dams in body weights at 6, 18 and 24 months of age and at first calving. It is, therefore, quite likely that the comparatively lower growth rate of the native non descript animals of Kerala, which formed the foundation stock for the crossbreeding programmes of the State is reflected to a certain extent, in the growth performances of the crossbreds as well.

5.1.2. Body measurements.

The summarised data on various height measurements presented in Table 10 indicate that while the average height of chest from the ground level increased from 48.00±0.46 to 53.81±0.91 cm and from 48.50+0.91 to 53.50+1.04 cm in crossbred Jersey and crossbred Brown Swiss heifer calves respectively, the average height at withers increased from 90.50±1.46 to 109.63+0.96 cm and from 91.50+2.04 to 108.06±1.91 cm respectively and the average height at rump increased from 94.13+1.6 to 112.13+0.92 cm and from 94.63+1.79 to 111 75±2.07 cm respectively during the entire period of 28 fortnights. The analysis of covariance of monthwise data on height of chest, withers and rump for the entire period taking the initial heights as the concomitant variable showed no significant differences between crossbred Jersey and crossbred Brown Swiss cattle in respect of these body measurements at any stage of growth. The analysis of covariance of data on final measurements are given in Tables 11, 12 and 13.

The data on girth measurements presented in Table 14 showed that while the average chest girth at the beginning and end of the experiment were 99.50+3.81 and 140.19+1.97 cm respectively in animals of group A, the same in animals of group B were 101.38+2.98 and 138.06+2.25 cm respectively The average paunch girth increased from 131 50+3 78 to 163 63+2 20 cm in animals of group A and from 128.50+3.60 to 158.69+3.59 cm in those of Group B and the flank girth increased from 103 88+3.22 to 144.13+2.64 cm in animals of Group A and from 105.50+3 35 to 144 25+3 52 cm in animals of Group B The analysis of covariance of monthwise data on chest girth, paunch girth and flank girth taking the initial measurements as concomitant variable showed no significant differences between the crossbred Jersey and Brown Swiss cattle in respect of these body measurements. The analysis of covariance of data on final measurements of chest girth, paunch girth and flank girth are presented in Tables 15, 16 and 17 respectively.

From the data presented in Table 18, it can be seen that the average measurements in cm at the beginning and end of the experiment in respect of body length, distance between shoulder points, distance between pin bones, distance from external angle of ileum to hip point and distance between hip points were 77.88+2 50 and 102.63+1 56, 25.38+0.68 and 39.13 0 99; 8.25+0.35 and 10.88+0.38, 19.06+0 18 and 24.13+0 30 and 36.13+1 09 and 51 63+0 80 respectively in animals of group A compared to 79.63+2 06 and 102 75+2 21; 24.50+0.89 and 38.75+1.05; 8 44+0.32 and 11.75+0 56, 18 75+0 31 and 23 75+0 41 and 36 50 1.51 and 51 38±1 90 respectively for animals of Group B The analyses of covariance of monthwar data on various length measurements of body, taking the initial values as concomitant variable indicated that there was no statistically significant difference between the two genetic groups in regard to any of the length measurements at any stage during the study. The analyses of covariance in respect of data on final measurements of body length, distance between shoulders, distance between pin bones, distance from ileum to hip point and distance between hip points are given in Tables 19, 20, 21, 22 and 23 respectively.

Literature available on body measurements of crossbred growing cattle in India in general and that of Kerala in particular, appears to be scanty. The stray reports available in the literature either pertains to short periods or to certain crossbreds only. According to Choudhury et al. (1975), the information pertaining to sire's influence and heritabilities on different body measurements are lacking in any type of crossbred cattle in India. They, however, observed significant differences between Jersey x Hariana and Holstein x Hariana in respect of their average body length, wither height, heart girth and paunch girth at first calving. They found that body length and paunch girth are significantly influenced by the sires in Jersey x Hariana females at first calving, whereas in Holstein x Hariana females, body length, wither height, heart girth and paunch girth were significantly influenced by the sires. Namjoshi and Katpatal (1983) reported that Friesian x Hariana half bred lactating cows measured more than Brown Swiss x Hariana and Jersey x Hariana cows. The absence of significant differences between the two crossbred groups noted in the present study in respect of various body measurements as in the case of their body weights corroborates the reports of significant correlation between the body weights and body measurements of cattle (Choudhury et al., 1975). Rao and

Parekh (1984) from their studies on five genetic groups of crossbred cattle concluded that by introducing different exotic paternal inheritance, there was no additive or dominant effect in different crossbreds for body growth when measured in terms of body weight, heart girth, body length and wither height at 24 months of age.

5.1.3. Feed consumption.

The data on fortnightly intake of dry matter computed from fortnightly intake of concentrate as well as roughage (Table 24 and Figs. 3, 4 and 10) showed that while animals in group A consumed on an average 58.17+2.50 kg of dry matter per fortnight during the entire period of experimentation, those in group B consumed on an average 59.69±2.69 kg of dry matter with an average daily intake of 4.16 and 4.26 kg of D.M. respectively. The statistical analyses of data on fortnightly intake of total dry matter presented in Table 24 showed no significant difference between crossbred Jersey and crossbred Brown Swiss heifers in this regard.

Comparative studies on growth rate and feed consumption carried out on different Kankrej crosses (Kankrej x Jersey F1 and Kankrej x Holstein Friesian F2) revealed that the average daily dry matter intake of Jersey crosses are higher than that of Holstein crosses (Panda and Sadhu, 1973; Singh, 1974 and Patel, 1978) Patel et al. (1985) reported that the average daily dry matter intake per 100 kg body weight of Jersey (3.20+0.08 kg) was significantly higher than that of Holstein crosses (2.90±0.06 kg) eventhough, the average dry matter intake per kg body weight gain was not significantly different.

The average dry matter intake of animals in the present study is essentially in keeping with the same observed by Taparia et al. (1983) who reported an average daily dry matter intake of 4.4 kg per day from their studies on crossbred heifers (Rathi/Gir x Red Dane) with an initial body weight of 91 to 151 kg, spread over a period of 168 days. Bhatnagar et al. (1975) reported that Brown Swiss x Sahiwal crossbreds of about 2 years of age consumed on an average 4.88±0.02 kg of D.M. daily. Virk et al. (1981) reported an average daily dry matter intake of 4.75±0.1 kg in half breds of Holstein Friesian, Brown Swiss and Jersey with Hariana, weighing on an average 88.25±3.51 and 119 00+4.46 kg respectively at the beginning and end of 56 days of study.

From the data on average daily dry matter intake of animals expressed in kg per 100 kg body weight and the statistical analysis of the same given in Table 25, it can be observed that the two groups did not differ significantly in this regard, the overall average consumptions being 3.26+0.05 and 3.33+0.12 kg respectively in the case of crossbred Jersey and crossbred Brown Swiss heifers. These results are essentially in keeping with those of Patel et al. (1985) who reported an average daily dry matter intake of 3.20+0.08 kg per 100 kg body weight in Jersey-Kankrej half breds from birth to one year of age. According to Thomas et al. (1969), Brown Swiss x Sahiwal heifers weighing on an average 213.62 kg consumed 2.358 kg of dry matter per 100 kg body weight during winter months. According to them, the overall mean dry matter intake per 100 kg body weight was significantly more in Sahiwal than in their crossbreds.

Taparia *et al.* (1983), however, reported average dry matter intake ranging from 2.49 to 2.74 kg per 100 kg body weight in 4 different groups of crossbred heifers (Gir/Rathi x Red Dane) fed on two different levels of protein and energy.

5.1.4. Water consumption.

It will be evident from the data on average fortnightly water intake and the statistical analysis of the same presented in Table 26 that the two cross bred groups of heifers failed to show any significant difference between each other in this respect, the overall average fortnightly water consumption in crossbred Jersey and Brown Swiss heifers, being 207.46±13.24 and 194.64+17.30 kg with average daily consumptions of 14.82 and 13.90 kg respectively during the period of 24 fortnights. The ratio of dry matter intake to water intake worked out to 1:4.55 and 1:4.17 respectively for the crossbred Jersey and crossbred Brown Swiss heifers.

The average daily water consumption of animals in the present study is well in agreement with the observations of Ranjhan and Daniel (1972) who reported an average daily water intake of 13.0 litres in Holstein x Hariana calves of 126 kg body weight as against 14.0 litres in Hariana calves weighing 133 kg. Taparia *et al* (1983) reported average daily water intake of 17.79, 18.7, 19.37 and 19.28 kg respectively in four groups of crossbred heifers (Gir x Red Dane) of 10 14 months of age. The ratio of dry matter intake to water intake varying from 1:3.9 to 1·4.37 reported by Taparia *et al.* (1983), are essentially in keeping with those of 1·4.55 and 1:4.17 observed for crossbred

Jersey and crossbred Brown Swiss heifer calves respectively in the present study. Similar observations were made by Mudgal and Ray (1965) and Singh and Mudgal (1967).

5.1.5. Haematological values.

a) Red cell and haemoglobin concentrations.

The data on red cell and haemoglobin concentrations and the statistical analyses thereof given in Table 27 show that the mean differences in the values in regard to the two groups of animals are not statistically significant. This is in accordance with the findings of Singla and Ludri (1981) who reported that the total erythrocyte counts in all the genetic grades of Brown Swiss x Sahiwal were not significantly different. The overall mean values of 9.04±0.16 and 9.00±0.12 for RBC in the case of Jersey and Brown Swiss crosses respectively and 10.49±0.12 and 10.51±0.14 respectively for haemoglobin are within the range of normal values reported for cattle (Kunjikutty,1969; Singh, 1972 and Jagannadhan et al., 1977).

b) Packed cell volume and plasma protein concentrations.

From the data on packed cell volume and plasma protein concentrations and the statistical analyses of the same given in Table 28, it can be seen that there is no significant difference between Jersey and Brown Swiss crosses in regard to these parameters. The overall average values of 33.56±0.99 and 33.13±1.17 for packed cell volume and 6.25±0.04 and 6.26±0.04 for plasma protein concentrations respectively observed for Jersey and Brown Swiss crosses are within the normal range reported (Kunjikutty, 1969; Jagannadhan et al., 1977 and Bhattacharyya et al., 1984).

c) Glutamic oxal acetic transaminase and Glutamic pyruvic transaminase levels in the serum.

From the data on SGOT and SGPT and statistical analyses thereof given in Table 29, it can be seen that there is no significant difference in their levels between crossbred Jersey and crossbred Brown Swiss heifers. Khub Singh and Bhattacharyya (1984) could not find any significant difference in the GOT and GPT activities in the serum of different exotic crosses of Hariana cattle. Erwin (1960) also, could not find any difference between Angus (Bos taurus), Brahman (Bos indicus) and their crosses. According to Bhattacharyy et al(1984), the change of transaminase activity in crossbreds was not related to either age or body weight in all the three types of crossbreds of Jersey x Hariana, Holstein x Hariana and Brown Swiss x Hariana, they studied. The overall average values of 40.60±0.65 and 41.10±0.63 for GOT and 12.34±0.28 and 12.36±0.22 for GPT respectively for crossbred Jersey and crossbred Brown Swiss heifers appear to be within the normal range already reported (Cornelius et al., 1959 and Medway et al., 1969).

From an overall assessment of the haematological values obtained during the course of the experiment, it may be observed that these values are essentially identical with those reported in the literature for cattle. Thus, adjudged from the concentrations of blood constituents, it is evident that the experimental subjects were apparently in sound nutritional state during the course of the study.

5.1.6. Digestibility of nutrients.

From the statistical analyses of data on digestion trial I (Table 30), it can be seen that the average digestion coefficients of 59.40±0.59, 61.29±0.78, 66.81±2.06 and 66.84±0.48 for dry matter, crude protein, crude fat and nitrogen free extract respectively in the case of crossbred Jersey are not significantly different from the average values of 59.55±1.60, 61.35±0.72, 66.32±1.49 and 65.26±1.76 respectively in the case of crossbred Brown Swiss animals. There is, however, significant difference (P/0.01) between the two genetic groups in respect of digestion coefficient of crude fibre, the average values being 55.68±1.28 and 62.27±1.12 respectively for groups A and B. But, there is no significant difference between the two groups in respect of average digestion coefficient of gross energy, the average values being 65.70±0.64 and 66.46±1.45 respectively for groups A and B.

The statistical analyses of data in digestion trial II (Table 31) show that there is no significant difference between the two crossbred groups (Groups A and B) in regard to the per cent digestibility of any of the nutrients, the average values for dry matter, crude protein, crude fat, crude fibre and nitrogen free extract being 58.99±1.02, 59 91±0.82, 66.18±0.92, 61.28±1.52 and 66.29±0.93 respectively for crossbred Jersey and 60.01±0.90, 60.74±0.62, 65.03±1.20, 63.75±1.09 and 66.89±0.66 respectively for crossbred Brown Swiss heifers. It can be observed that the two groups did not differ significantly in regard to the digestibility of gross energy also, the average coefficients being 66.62±0.91 and 67.24±0.82 respectively for groups A and B.

The results given above are in agreement with the findings of Howes et al. (1963) who reported that there was no significant difference between Zebu and European breeds in regard to dry matter digestibility. Thomas et al. (1969), however, reported significantly higher digestibility coefficients in respect of crude fibre and ether extract in Brown Swiss x Sahiwal compared to Sahiwal. But, they could not find any significant difference in regard to digestibility of NFE and crude protein. Krishna Mohan (1978) could not find any significant difference in the percentage digestibility of dry matter in crosses of Holstein Friesian or Brown Swiss with Hariana. Singh and Bhat (1979) from their studies on different crossbreds (Hariana x Holstein Friesian, Hariana x Brown Swiss and Hariana x Jersey) concluded that there were no significant differences between the different genetic groups in respect of digestibilities of different nutrients.

The digestion coefficients noted in both the genetic groups during the present study are comparable with the average values of 63.81±2.31, 60.09±2.10, 63.61±1.78, 65.34±2.33 and 65 71±1.02 for dry matter, crude protein, ether extract, crude fibre and nitrogen free extract respectively reported by Virk et al. (1981) in half breds of Holstein-Friesian, Brown Swiss and Jersey with Hariana. They also could not find any significant difference between the different genetic groups in regard to the percentage digestibility of various organic nutrients. Kurar et al (1984) also reported similar values in respect of dry matter, crude protein and ether extract in Karan Swiss eventhough, they observed a slightly higher digestibility percentage of 72 09±0.81 for crude fibre and a lower value of 56.13±0.75 for NFE. Kurar et al. (1987), however, reported apparent digestibility coefficients of 65.68 and 46.75 for dry matter and crude protein respectively in Holstein Friesian x Sahiwal (F1) male calves of 197 days of average age and weighing on an average 90.3 kg. Sreenivasa Mohan et al. (1987) reported average digestibility coefficients of 69.63±0.91, 64.70±0.82, 61.70±0.84, 65.55±1.33 and 76.46±1.36 for dry matter, crude protein, ether extract, crude fibre and NFE respectively in the case of Ongole x Jersey heifers with an average body weight of 88.20±12.23 kg when fed as per N.R.C. Standard.

From the foregoing paragraphs, it can reasonably be concluded that the minor variations in the digestibility coefficients of various nutrients reported by some of the authors in the past are attributable to the differences in the various dietary factors involved rather than due to any genetic factor and that the present study on two genetic groups of crossbred Jersey and crossbred Brown Swiss cattle failed to show any significant difference in their ability to digest various organic nutrients of their rations.

5.1.7. Feed utilisation.

a) Dry matter.

The data on the average daily consumption of dry matter by heifer calves and the statistical analysis of the same given in Table 32 and Figs. 3 and 4 show that there is no significant difference between the two genetic groups in respect of their dry matter intake in g per unit metabolic body size ($W^{0.75}_{kg}$), the overall average consumption being 108.08±0.84 and 107.19±2.24 g respectively for crossbred Jersey and crossbred Brown Swiss heifer calves.

The average dry matter consumtpion per unit metabolic body size of animals in the present study is within the range of 87.4 to 125.6 g per kg $W^{0.75}$ reported by Katiyar et al. (1972). Taparia et al. (1983) have reported an average dry matter intake of 90.49 99.66 g/$w_{kg}^{0.75}$ for crossbred heifers (Gir/ Rathi x Red Dane) of 10-14 months of age. The dry matter intake of 3.47 and 3.54 kg per 100 kg metabolic body size respectively in the case of cross-bred and Sahiwal bull calves of 11/2 to 21/2 years of age reported by Bhatnagar et al. (1975), is much lower than the average values obtained in the present study. However, the average dry matter consumption of 96.19 g per $W_{kg}^{0.75}$ reported by Kurar et al. (1987) is more or less close to the observations made during the present study.

Data on feed efficiency in terms of dry matter consumption per kg weight gain and the statistical analysis thereof presented in Table 33 indicate that the crossbred Jersey heifer calves did not differ significantly from crossbred Brown Swiss calves in this regard, the overall average ratio being 13.70 ± 1.01 and 14.80 ± 1.06 respectively for the two genetic groups. Virk et al. (1981) also could not observe any significant difference between crossbred Jersey, Brown Swiss and Holstein heifers in this regard. They reported an average weight gain of 10.68 ± 0.43 and 10.71 ± 0.33 g per 100 g dry matter intake in two experiments on half breds. Kurar et al. (1984) however, reported a dry matter efficiency of 8.649 ± 0.514 in Karan Swiss heifers of 6 10 months of age. Patel et al. (1985) could not find any significant difference between Jersey and Holstein crosses of Kankrej with an average efficiency value of

10.11±1.6 and 9.82±0.9 kg DM per kg weight gain respectively. They also observed that the DM consumption per kg weight gain increased with the age and a similar trend has been observed in the present study as well.

b) Gross energy.

It can be seen from the statistical analyses of data on gross energy intake of animals given in Table 34 and Figs. 5, 6 and 10 that the fortnightly gross energy intakes of crossbred Jersey and crossbred Brown Swiss heifer calves are not significantly different from each other, the overall averages being 237.20±9.85 and 245.44±10.73 Mcal respectively for the two groups. Similarly, it can be seen from Table 35 that the two crossbred groups did not differ significantly in respect of their average daily gross energy consumption, the overall average figures being 442.40±3.59 and 442.42±8.50 Kcal per unit metabolic body size ($W^{0.75}_{kg}$) for crossbred Jersey and crossbred Brown Swiss calves respectively. The data on average consumption of gross energy per kg weight gain and the statistical analysis of the same given in Table 36 show that the two groups did not differ significantly in this respect, the overall mean values being 54.25±3.13 and 61.47±4.47 Mcal for groups A and B respectively

Keshavamurthy (1973) reported an average daily intake of 23455 and 22516 Kcal of gross energy in crossbred and Sahiwal heifer calves of about two years of age respectively

The average daily gross energy intake of 445.29±18.56 Kcal per $W^{0.75}_{kg}$ reported by Kurar et al (1987) based on their studies on Holstein x Sahiwal male calves weighing on an average 90.3 kg spread over a period of three months is akin to the results obtained in the present study.

The average gross energy consumption per unit weight gain (kg) in the present study is comparable to the average values of 48.5 and 58.7 Mcal respectively reported by Bhatnagar et al. (1975) in the case of crossbred and Sahiwal calves of 9-12 months of age.

c) Total digestible nutrients.

The statistical analyses of data on the utilisation of total digestible nutrients in terms of average fortnightly intake in kg (Table 37 and Figs. 7 and 10), average daily intake in kg (Table 38), average daily intake in g/$W_{kg}^{0.75}$ (Table 39) and average intake in kg/kg weight gain (Table 40) showed no significant differences between the two groups in these respects, the overall average values being 35.22±1.54, 2.52±0.11, 65.50±0 50 and 8.09±0.46 respectively for crossbred Jersey and 36.60±1.62, 2.61±0.12, 65.80±1.30 and 9.17±0.68 respectively for crossbred Brown Swiss calves.

The average TDN intake in kg/day in the present study is well within the range of 2.47 3.07 reported by Taparia et al. (1983) for Gir/Rathi x Red Dane heifers of 10-14 months of age. Virk et al. (1981) reported an average daily TDN intake of 2.82±0.74 - 3.77±1.20 in Hariana half breds of Holstein, Brown Swiss and Jersey. They reported an average TDN consumption of 5.3 - 5.5 kg per kg weight gain. Saha and Ray (1987) reported an average TDN intake of 4.75±0.44 - 5.00±0.33 kg/kg weight gain in Hariana crossbreds of 6 8 months of age based on the results of a study spread over a period of 197 days. Bhatnagar et al. (1975) reported an average daily TDN intake of 2.13 kg/100 kg metabolic body weight. The comparatively higher values of average TDN intake per $W_{kg}^{0.75}$ as well as those per unit weight gain in the present study are attributable to the relatively lower growth rate of cross bred animals of Kerala and to differences in the net energy values of the rations used. However, the results clearly indicate that the two crossbred groups did not differ significantly in regard to their efficiency of utilisation of TDN for growth

d) Digestible energy.

There is no statistically significant difference between crossbred Jersey and crossbred Brown Swiss heifers in respect of their average fortnightly intake of digestible energy (Table 41 and Figs. 8 and 10), average daily intake/ $W_{kg}^{0.75}$ (Table 42) and average intake in Mcal/kg weight gain (Table 43), the overall averages being 158.84±6.73 Mcal, 295.37±2.37 Kcal and 36.32±2.09 Mcal respectively for Jersey crossbreds and 164.20±7.17 Mcal, 295.52±5.71 Kcal and 41.19±3.00 Mcal respectively for Brown Swiss crossbreds.

The average fortnightly intake of 158.84±6.73 Mcal (11.35 Mcal/day) and 164.20±7.17 Mcal (11.73 Mcal/day) of DE by animals of groups A and B respectively in the present study are in agreement with the average values of 11.84±0.23 and 12.02±0.30 respectively reported for half breds by Virk et al (1981) based on two experiments conducted on Holstein Friesian, Brown Swiss and Jersey crosses of Hariana cattle of about 7 months old for a period of 56 days and 172 days respectively They failed to find any significant difference between the different genetic groups in respect of the average daily intake of digestible energy.

The average digestible energy intake in terms of Kcal/$W_{kg}^{0.75}$ obtained in the present study also compares well with the average DE intake of 306 Kcal/ $W_{kg}^{0.75}$ reported by Kurar et al. (1987) for Holstein-Friesian x Sahiwal crossbred heifer calves fed as per Sen et al. (1978) standard.

e) Crude protein.

The data on crude protein intake and the statistical analysis of the same given in Table 44 indicate that the average fortnightly crude protein intake of crossbred Jersey heifers is not significantly different from that of cross bred Brown Swiss heifers, the overall averages in this regard being 8.19$\pm$0.40 and 7.96$\pm$0.23 kg which amounts to a daily average intake of 585 and 569 g respectively.

The data given in Table 45 suggest that the two genetic groups of heifers did not differ significantly in respect of their crude protein intake per unit metabolic body size ($W_{kg}^{0.75}$) , the overall average values in this regard being 14.86$\pm$0.14 and 14.72$\pm$0.27 g respectively for the two groups A and B. The average crude protein intake per unit metabolic body size of heifers in the present study is essentially in keeping with the observations of Kurar et al.(1987) who reported an average crude protein intake of 16.98+0.50 g per $W_{kg}^{0.75}$ in the case of crossbred (Holstein Friesian x Sahiwal) male calves weighing on an average 90.3 kg and fed as per the standard set by Sen et al. (1978).

The data on average crude protein intake in kg/kg weight gain in heifer calves and the statistical analysis thereon given in Table 46 indicate that the two groups did not differ significantly in this regard. The overall average consumption of crude protein per kg weight gain in crossbred Jersey and cross bred Brown Swiss heifers in the present study are 1.83±0.10 and 2.03±0.14 kg respectively.

f) Digestible crude protein.

It can be observed from Table 47 and Figs. 9 and 10 that the fortnightly intake of digestible crude protein by crossbred Jersey heifers with an overall average of 4.82±0.16 kg is not significantly different from that of crossbred Brown Swiss having an overall average consumption of 4.94±0.17 kg. Taparia et al. (1983) reported an average daily DCP intake ranging from 266 7 to 369.0 g in crossbred heifers (Gir x Red Dane) weighing 173.7 to 175.9 kg This is comparable with the average fortnightly intake of 4.82±0.16 (344.3 g/day) and 4.94±0.17 kg (352.9 g/day) respectively for group A and B in the present study. Virk et al. (1981) reported an average daily DCP consumption of 296.97±6.06 g in half breds of Holstein, Brown Swiss and Jersey with Hariana during the period when their body weight increased from 88.25±3.51 to 119.00±4.46 kg.

The data on average daily consumption of DCP in $g/W_{kg}^{0.75}$ and the statistical analysis of the same, given in Table 48 suggest that there is no significant difference between the two genetic groups in this regard, the overall average values being 9.08±0.09 and 9.00±0.16 g respectively for groups A and B The average daily DCP intake of animals in the present study are within the range of 9.20 to 21.99 g per unit metabolic body size reported by Katiyar et al. (1972) in the case of Friesian, Brown Swiss and Jersey crosses of Hariana Krishna Mohan and Ranjhan (1982), however, reported an average daily DCP intake of 6 2 g per $W_{kg}^{0.75}$ in crossbred Hariana x Brown Swiss and Hariana x Holstein of 3 7 months of age fed as per NRC standard. They concluded that the level of protein can be reduced below the existing standards for growing crossbred heifers without adversely affecting their growth rate. The average DCP intake of 9.8 g per day/$W_{kg}^{0.75}$ reported by Gupta and Saha (1984) in the case of Hariana x Holstein heifers weighing 62-121 kg when fed as per Morrison standard, is in accordance with the DCP intakes of animals in the present study. Kurar et al. (1987) reported an average DCP intake of 7.49±0.23 g per $W_{kg}^{0.75}$ in crossbred (Holstein x Sahiwal) male calves weighing on an average 90.3 kg in a three month's study. A little higher value obtained in the present study can be partly attributed to the differences in the rations used and partly to the comparatively lower growth rate of animals.

It can be seen from the summarised data onDCP consumption and the statistical analysis thereof given in Table 49 that there is no significant difference between crossbred Jersey and crossbred Brown Swiss heifer calves in respect of their average DCP consumption per kg weight gain, the overall means for the two groups A and B being 1.10±0.06 and 1.24±0 08 kg respectively. The average protein efficiency values in terms of DCP required per unit gain in animals in the present study are essentially in keeping with the values of 0.91±0.09 and 0.96±0.06 respectively reported by Saha and Ray (1987) for two groups of Holstein and Jersey crosses of Hariana

g) Nitrogen balance.

The data on Nitrogen balance studies carried out at the middle of the experiment and at the end of the experiment and the statistical analyses of the same presented in Table 50 show that there is no significant difference between the two groups in respect of the efficiency of utilisation of protein in their rations in terms of average nitrogen balance both at the middle and end of the experimental period, the average percentage of consumed nitrogen retained being 19.01±0.82 and 18.21±0.98 respectively for Groups A and B during balance trial I and 16.60±1.02 and 17.04±0.75 respectively during balance trial II. The average daily nitrogen retention of 18.48±0.61 and 18.06±1.02 g for groups A and B at the middle of the experiment as well as the corresponding values of 17.90±1.02 and 18.86±1.15 g at the end of the experiment respectively are within the range of 19.45 - 28.72 g per day reported by Taparia et al. (1983) based on their studies on crossbred heifers (Gir/Rathi x Red Dane) of 10-14 months weighing 91 to 151 kg and fed at different levels of energy and protein.

The average daily nitrogen retention of animals in the present study are in keeping with the observations of Sreenivasa Mohan et al. (1987) who reported an average daily nitrogen retention of 18.39±1.89 g forming 27.60±3.03 per cent of intake, in Ongole Jersey crossbred heifers weighing 88 20±12.23 kg, fed at NRC standard.

Part II

5.2. Lactation Study

5.2.1. Body weight.

From the summarised data on fortnightly body weights presented in Table 51, it can be seen that while animals in the crossbred Jersey group weighed on an average 266.00±8.48, 276.33±8.61 and 285.50±9.96 kg respectively during the 1st, 7th and 13th fortnight, those in crossbred Brown Swiss group weighed on an average 275.75±16 13, 286.42±15.93 and 296.50±17.21 kg respectively during the same period. The analysis of covariance of data on fortnightly body weights of animals in the two groups taking the initial body weight as the concomitant variable showed that there was no significant difference between them in this respect during any of the fortnights studied. The analysis of covariance of data for 1st, 7th and 13th fortnights are presented in Tables 52, 53 and 54 respectively.

It can be seen from the data on fortnightly weight gain of animals presented in Table 51 that cows in both the genetic groups were not only maintaining their body weights but were also gaining weight regularly, the average fortnightly weight gain being 1.44±0.14 kg in the case of crossbred Jersey cows compared to 1.71±0.06 kg in the case of crossbred Brown Swiss cows. The analysis of variance of data on fortnightly weight gain taking the initial weight gain as the concomitant variable showed that there was no significant difference between crossbred Jersey and crossbred Brown Swiss cows in this respect during any of the 13 fortnights. The analysis of variance in respect of 2nd, 7th and 13th fortnights are presented in Tables 55, 56 and 57 respectively

Pradhan et al. (1975) reported an appreciable weight gain of 19 0, 31.2, 31.2 and 24.6 kg respectively in lactating half breds of Holstein, Brown Swiss, Red Dane and Jersey cows during a period of 12 weeks when fed according to the upper level of Morrison's feeding standard (Morrison, 1984), thereby indicating that those animals were fed more than their requirements for maintenance and milk production. Singh et al. (1977) also reported an average weight gain of 13.0 and 25.4 kg respectively by half breds of Jersey x Hariana and Brown Swiss x Hariana cows during an experimental period of 12 weeks. It is a well established fact that the conversion of nutrients into milk is more efficient than their first conversion into body tissue and then into milk (Flatt and Cappock, 1965 and Flatt et al., 1967). The need to feed lactating cows at a level to obtain minimum weight gain has been stressed. The weight gain of animals in the present study, however, was only less than half of that reported by Pradhan et al. (1975) and hence,it can reasonably be inferred that the animals in the present study were not overfed.

5.2.2. Feed consumption.

From the summarised data presented in Table 58, it can be seen that while animals in group I consumed on an average 60.09±3.55, 58.92±3.05 and 55.42±2.10 kg respectively of concentrate and 448 13±13.47, 389 54±18.22 and 425.33±14.74 kg respectively of roughage during the 1st, 7th and 13th fortnights and those in group II consumed on an average 60.75±2.74, 60.75±2.74 and 56.58±4.82 kg of concentrate and 451.62±21.94, 393.42±18.98 and 425.13±18.71 kg respectively of roughage during the same period.

The analysis of covariance of data on fortnightly consumption of concen trate and roughage by the two groups of cows, taking the values in respect of the first fortnight as concomitant variable showed that they do not differ significantly in regard to their consumption of concentrate and roughage during any of the 13 fortnights studied except that during the 2nd fortnight cross-bred Jersey cows consumed significantly more roughage (446.99±12.5 kg) compared to crossbred Brown Swiss (433.47±21.64 kg) which might probably be due to some unknown variables rather than due to any breed factor The analysis of covariance in respect of concentrate intake during the 13th fortnight is given in Table 59 and that in respect of roughage intake during the 2nd, 7th and 13th fortnights are presented in Tables 60, 61 and 62 respectively.

It can be seen from Table 63 that crossbred Jersey cows consumed on an average 145.36±5.48, 153.03±6.70 and 153.45±5.19 kg of dry matter per fortnight with an average daily consumption of 3.92±0.22, 4.01±0.26 and 3.90±0.23 kg per 100 kg body weight during the 1st, 7th and 13th fortnights respectively as compared to fortnightly consumptions of 146.68±6.68, 155.68±7.29 and 156.30±8.99 kg and daily consumptions of 3.90±0.29, 3.98±0.30 and 3.87±0.34 kg respectively of dry matter by crossbred Brown Swiss cows during the same fortnights.

The summarised data presented in Table 63 showthat roughage concentrate ratio of the total dry matter consumed by the cows in groups I and II increased from 1.63±0.08 and 1.54±0.09 respectively during the first fortnight to 2.05±0.05 and 2.09±0.15 respectively during the 13th fortnight.

The analysis of covariance of data on fortnightly intake of dry matter and average daily intake of dry matter per 100 kg body weight, taking the values for the first fortnight as concomitant variable showed that the two groups of crossbred cows did not differ significantly in these respects during any of the fortnights studied except that crossbred Jersey cows consumed significantly more (P $\angle$0.05) dry matter per fortnight (145.22±5.29 kg) as well as per day per 100 kg body weight (3 90±0.23 kg) during the 2nd fortnight compared to crossbred Brown Swiss cows (143.17±6.63 and 3.77±0 26 kg respectively), evidently on account of higher roughage intake already discussed.

There is also no statistically significant difference between the two groups of cows in respect of the roughage concentrate ratio of the total dry matter consumed by them during any of the 13 fortnights. The analysis of co-variance in respect of fortnightly dry matter consumption, daily dry matter consumption per 100 kg body weight and the roughage concentrate ratio are presented in Tables 64 to 66, 67 to 69 and 70 respectively.

The dry matter consumption of animals in the present study are in keeping with the average daily dry matter consumption of 10.38 kg reported by Bhatnagar et al. (1976) in the case of crossbred Brown Swiss cows Pradhan et al. (1975), however, reported a slightly higher average daily dry matter intake of 11.70±0.35, 10.36±0.31, 10.93±0 36 and 10.66±0.11 kg respectively by Holstein, Brown Swiss, Red Dane and Jersey half breds of Hariana. Raina et al. (1976) reported an average daily dry matter intake of 13.552±0.272 kg in F1 Brown Swiss Sahiwal crossbred milch cows. Sharma et al. (1976) have reported an average daily dry matter intake of 13.33 and 13.55 kg respectively for Sahiwal and Sahiwal Brown Swiss crossbred cows. Singh et al. (1977) reported an average daily dry matter intake of 12.37 and 11.97 kg respectively in half breds of Jersey x Hariana and Brown Swiss x Hariana in a 12 week study.

According to Bhatnagar et al. (1975), fodder consumption of Brown Swiss x Sahiwal crossbred cows varied from 3 5 per cent of their body weight on dry matter basis when fed ad lib. The average daily dry matter consumption of 3.94 and 3.92 kg per 100 kg body weight of crossbred Jersey and crossbred Brown Swiss cows respectively in the present study are comparable with the average daily dry matter consumption of 3.79 kg per 100 kg body weight reported by Bharadwaj et al. (1976) in the case of hald bred (Holstein x Thari) milch cows fed ad lib.

The observation in the present study that crossbred Jersey cows failed to differ significantly from crossbred Brown Swiss cows in respect of their daily dry matter consumption is in accordance with the observations of Singh et al. (1976).

5.2.3. Digestibility of nutrients.

From the summarised data on digestion coefficients of nutrients and the statistical analysis presented in Table 71, it can be seen that there is no significant difference between crossbred Jersey and crossbred Brown Swiss in respect of their ability to digest dry matter, crude protein, ether extract, crude fibre and nitrogen free extract, the average values being 52.54+1.97, 60.73+1.26, 57.66+2.15, 51.11+2.43 and 60.44±1.82 respectively for the former and 51.97+1.61 60.05+1.89, 56.35+2.42, 49.81+1.21 and 59.99+1.77 respectively for the latter. It can also be observed that both the groups did not differ significantly in respect of digestibility of gross energy as well, the average coefficients being 55.40+1.97 and 55.81+1.79 respectively for animals in groups I and II.

The average digestion coefficients of various nutrients in the case of milch animals in the present study are essentially in keeping with those reported by Kakkar and Mudgal (1978) for lactating cows. The average values, however, are slightly lower than those obtained in the present investigation with heifers (Part I).

The average digestion coefficients of 54.14 , 58.58, 68.05, 54 73 and 59.00 for dry matter, crude protein, ether extract, crude fibre and nitrogen free extract respectively reported in half bred (Thari x Holstein) milch cows fed on a high energy (70 per cent TDN) conventional ration as per NRC standard (Bharadwaj et al. 1976) are essentially in keeping with the results obtained in the present study except in respect of ether extract for which a higher value has been reported. They, however, concluded that the higher level of energy in tne concentrate mixture used in their study might be responsible for the higher digestibility of ether extract.

5.2.4 Haematological values.

From the summarised data given in Table 72, it can be seen that the average RBC counts at the beginning, middle and end of the experiment were 9.71±0.33, 9.49±0.27 and 9.67±0 29 millions per mm^3 respectively in crossbred Jersey cows and 9.29±0.29, 9.58±0.27 and 9.23±0.15 millions per mm^3 respectively in crossbred Brown Swiss cows. The haemoglobin concentrations during the same fortnights were 10.10±0.42, 10.47±0.32 and 10.12±0.34 g per 100 ml respectively in animals of Group I and 10.23±0.32, 10.32±0.33 and 10 38±0 21 g per 100 ml respectively in those of Group II. In respect of plasma protein concentration, the corresponding values were 7.09±0.11, 8.06±0.27 and 7.72±0.23 g per 100 ml in cows of group I and 7.04±0.15, 7.44±0.22 and 7.72±0.27 g per 100 ml in those of group II

The analysis of variance of data on haematological values taking the data for the first fortnight as concomitant variable showed that there were no significant differences between crossbred Jersey and crossbred Brown Swiss cows in respect of RBC, haemoglobin and plasma protein concentrations during any of the 13 fortnights except during the 12th fortnight when crossbred Jersey cows showed significantly higher (P/0.05) values of 9.89 ± 0.14 and 8.07 ± 0.14 in respect of RBC and plasma protein concentrations respectively as compared to 9.30 ± 0.20 and 7.48 ± 0.22 respectively in crossbred Brown Swiss cows. The analysis of variance in respect of RBC, haemoglobin and plasma protein concentrations pertaining to 13th fortnight are given in Tables 73, 74 and 75 respectively.

The data on red cell and haemoglobin concentrations obtained in respect of lactating cows used in the present study are comparable with those reported by Jagannadhan et al. (1977) in the case of Jersey and Holstein crosses of Tharparkar Singla and Ludhri (1981), however, reported much lower RBC counts (7.8 million/mm^3) in Brown Swiss x Sahiwal crosses eventhough the haemoglobin and plasma protein concentrations reported by them were in keeping with the values obtained in the present study. Prakash and Tandon (1978) reported a decrease in haemoglobin values during lactations in Holstein x Tharparkar cows. The haemoglobin values ranging from 10.8 to 11.1 g per 100 ml reported by them are comparable with the values obtained in the present study.

From an overall assessment of the haematological values in respect of red cell, haemoglobin and plasma protein concentrations observed in the present study, it can reasonably be surmised that the values were within the range reported as physiological norms for cattle and that the animals were in good nutriture (Spector, 1956).

5.2.5. Milk yield.

It can be seen from the summarised data given in Table 76 that the average fortnightly milk yields of crossbred Jersey cows during the 1st, 7th and 13th fortnights were 101.92±6.75, 98.88±3.44 and 89.95±6.40 kg with average daily yields of 7.28, 7.06 and 6.43 kg respectively compared to fortnightly mlk yields of 99.00±4.80, 99.18±5.32 and 95.18±8.72 kg with average daily yields of 7.07, 7.08 and 6.80 kg respectively in the case of crossbred Brown Swiss cows.

The analysis of covariance of data on fortnightly milk yield of cows belonging to the two genetic groups taking the data for the first fortnight as concomitant variable showed that they did not differ significantly in this regard during any of the fortnights studied except during the 4th fortnight when crossbred Brown Swiss cows produced (99.32±4.52 kg) significantly more milk ($P < 0.05$) than crossbred Jersey cows (95.95±4.79 kg). The analysis of covariance in respect of 2nd and 7th fortnights and analysis of variance in respect of 13th fortnight are given in Tables 77, 78 and 79 respectively.

These results are comparable with those of Pradhan *et al.* (1975) who reported average daily milk yield of 7.50±0.47 and 6.80±0.57 kg respectively in the case of half breds of Hariana with Jersey and Brown Swiss when animals were fed at the upper level of Morrison feeding standard. However, singh et al. (1977) reported an average daily milk yield of 10.37 and 8.69 kg respectively in the case of half breds of Jersey x Hariana and Brown Swiss x Hariana in a 12 week study. Stephen et al. (1985) from an analysis of records of first lactation milk yields of Jersey x local and Brown Swiss x local cows reared by the farmers of Indo Swiss project area and those under the intensive cattle development areas of Kerala state concluded that there is no significant difference between Jersey and Brown Swiss crosses in this respect. According to Mukundan and Mathew (1983), both Jersey and Brown Swiss crosses performed equally well.

5.2.6. Composition of milk.

The summarised data presented in Table 80 show that the average values in per cent in respect of milk constituents of animals belonging to group I during the 1st, 7th and 13th fortnights were 13.12±0.19, 13.26±0.17 and 13.28±0.16 respectively for total solids; 8.17±0.19, 8.26±0.22 and 8.18±0.15 respectively for solids not fat; 4.95±0.20, 5.00±0.06 and 5.10±0.06 respectively for fat and 3.51±0 03, 3.53±0.04 and 3.61±0.03 respectively for protein as compared to average values of 12.70±0.12, 13.12_0.12 and 13.40±0.24 respectively for total solids; 7.95±0.08, 8.17±0.14 and 8.32±0.23 respectively for solids not fat; 4.75±0.15, 4.95±0.07 and 5.08±0.05 respectively for fat and 3.49±0.03, 3.46±0.04 and 3.62±0.03 respectively for protein in the case of animals belonging to group II.

From the analysis of covariance of fortnightly data on milk constituents taking the values for the first fortnight as concomitant variable, it can be observed that the two groups of crossbred cows did not differ significantly in respect of any of the constituents throughout the experimental period of 13 fortnights except during the 6th fortnight when the milk produced by crossbred Jersey had significantly higher (P /0.05) contents of total solids and fat (13.60+0.14 and 5.03+0.05 per cent respectively) than those of crossbred Brown Swiss cows (13.06±0.14 and 4.78±0.08 per cent respectively). The analysis of variance in respect of total solids, solids not fat, fat and protein content of milk during the 13th fortnight are given in Tables 81, 82, 83 and 84 respectively.

Pradhan et al. (1975) reported average fat and solids not fat content of 5.7 and 9.2 per cent respectively for Jersey x Hariana crosses compared to 5.1 and 9.3 per cent respectively for Brown Swiss x Hariana crosses, the difference being significant (P /0.05) in respect of fat. The average milk fat content ranging from 4.42 to 5.15 per cent reported by Chawla and Mishra (1976) for Brown Swiss crosses of Red Sindhi and Sahiwal is well in keeping with the results obtained in the present study, while the average milk fat content of 4.5 per cent reported by Basu et al. (1962) for crossbred cattle is little lower than the present observation. Similarly, the average milk fat content of both the groups of animals in the present study are higher than the average fat content of 4.10+0.07 per cent reported for Holstein crosses of Hariana by Singh et al. (1976) eventhough the average SNF content of 8.22+0.04 reported by them is in accordance with the present results. Singh et al. (1977) could not find any significant difference between crossbred Jersey and crossbred

Brown Swiss cows in respect of SNF content of their milk while the milk of crossbred Jersey had significantly higher fat content (P/0.05). The average SNF contents of 8.51 and 8.38 per cent reported by these authors in the case of Jersey and Brown Swiss crosses of Hariana respectively are in keeping with the results obtained in the present study.

5.2.7. Production of butter fat and fat corrected milk (FCM).

The summarised data on fortnightly production of butter fat and statis tical analysis thereof presented in Table 85 indicate that there is no signifi cant difference between crossbred Jersey and crossbred Brown Swiss cows in this regard, the overall average fortnightly production being 4.79±0.18 and 4.73±0.26 kg of butter fat respectively for the two crossbred groups.

From the data on fortnightly production of FCM by crossbred Brown Swiss cows summarised in Table 86 and Figs. 12 and 22, it can be seen that while cows in group I gave on an average 116.06±6.79, 113.69±3.89 and 104.82±7 67 kg respectively of FCM during the 1st, 7th and 13th fortnights, those in group II produced on an average 109.93±4.95, 113.38±6.40 and 107.32±11 93 kg respectively of FCM. The analysis of covariance of data on fortnightly pro duction of FCM by the two groups of cows, taking the values in respect of first fortnight as concomitant variable showed that there is no significant difference between them in this regard during any of the 13 fortnights. The analysis of covariance in respect of 13th fortnight is given in Table 87.

Pradhan et al. (1975) have reported average FCM yields of 9 3 and 8.8 kg per day respectively by Jersey and Brown Swiss crosses of Hariana. These observations are in keeping with those of present study. However, from a com parative study involving half breds of Holstein Brown Swiss and Jersey with Hariana, Singh et al. (1977) reported highest FCM yield (P /0.01) in Jersey crosses which they attributed to the higher percentage of fat in the milk of Jersey cows.

5.2.8. Production of total solids and solids corrected milk(SCM).

It can be seen from the summarised data on average fortnightly yield of total solids and the statistical analysis of the same given in Table 88 and Figs. 13 and 22 that there is no significant difference between crossbred Jersey and crossbred Brown Swiss cows in this regard. While crossbred Jersey cows produced on an average 12.59±0.47 kg of total solids per fortnight, crossbred Brown Swiss cows produced on an average 12.69±0.67 kg of total solids. Simi larly, the summarised data on fortnightly yield of solids corrected milk and the statistical analysis of the same presented in Tables 89 and Fig 13 also show that crossbred Jersey and crossbred Brown Swiss cows are not signifi cantly different in this respect, the overall average fortnightly yields being 102.97±3.82 and 103.10±5.47 kg for animals in group I and II respectively.

5.2.9. Feed utilisation.

a) Dry matter

From the summarised data on fortnightly consumption of dry matter presented in Table 90, it can be seen that while cows in group I consumed on an average 158.13±8.17, 162.88±9.50 and 159.75±8.33 g of dry matter per day per $W_{kg}^{0.75}$ during the 1st, 7th and 13th fortnights respectively, those in group II consumed on an average 157.58±9.86, 162.43±10.48 and 159.23±12.37 g of dry matter per $W_{kg}^{0.75}$ respectively during the same period.

From the analysis of covariance of fortnightly data on dry matter consumption per $W_{kg}^{0.75}$ for all the fortnights taking the values for the first fortnight as concomitant variable it was observed that there was no significant difference between crossbred Jersey and crossbred Brown Swiss cows in this regard during any of the fortnights except during the second fortnight when the average daily dry matter consumption of 157.53±8.30 g per $W_{kg}^{0.75}$ by the former was found to be significantly higher (P ∠0.05) than the average consumption of 152.90±9.18 g by the latter. The analysis of covariance in respect of data for the 13th fortnight is given in Table 91.

It can be seen from the summarised data presented in Table 90 that cross bred Jersey cows consumed on an average 1.27±0.06, 1.35±0.05 and 1.50±0.12 kg respectively of dry matter per kg of FCM produced during the 1st, 7th and 13th fortnights as compared to 1.41±0.07, 1.44±0.07 and 1.52±0.08 kg respectively by the animals in the crossbred Brown Swiss group during the same period. From the analysis of covariance of fortnightly data on dry matter required for the production of one kg of FCM (including maintenance) taking the data for the first fortnight as the concomitant variable, it was found that the two genetic groups did not differ significantly in this respect. The analysis of covariance in respect of data for 13th fortnight is given in Table 92

The average dry matter consumption per unit metabolic body size ($W_{kg}^{0.75}$) in respect of animals in the present study are well within the range of 106 5 to 165.1 g reported by Brahmakshatriya and Donker (1975) for Holstein cows.

Sharma et al. (1976) reported a higher average dry matter consumption of 18.14 kg per 100 $W^{0.75}_{kg}$ in Brown Swiss x Sahiwal crossbred cows. According to Raina et al. (1975), Brown Swiss x Sahiwal crossbred lactating cows utilised 1.004 kg of dry matter for the production of one kg of fat corrected milk. Pradhan et al. (1975) reported an average dry matter con sumption of 1.15 kg per kg of FCM produced by crossbred Jersey cows as against 1.18 kg by crossbred Brown Swiss cows. Singh et al. (1976) have reported an average DM consumption of 1.03 and 1.31 kg per kg of FCM pro duced by half breds of Jersey x Hariana and Brown Swiss x Hariana cows respectively with average daily SCM yields of 12 05 and 9.14 kg respectively The higher requirement of DM to produce one kg of FCM in the present study can be attributed partly to the lower per day yield of FCM by animals belonging to the two genetic groups.

b) Gross energy.

It can be seen from the summarised data on fortnightly consumption of gross energy and the statistical analysis thereof given in Table 93 and Figs. 14 and 22 that there is no significant difference between the two genetic groups of cows in this respect, the overall average fortnightly consumptions being 621.79$\pm$23.14 and 631.59$\pm$29.76 Mcal respectively for crossbred Jersey and crossbred Brown Swiss cows with average daily consumptions of 44 41 and 45.11 Mcal by the two groups of cows.

The summarised data on average daily intake of gross energy (Kcal) per $W^{0.75}_{kg}$ and the statistical analysis thereof given in Table 94 show that crossbred

Jersey cows are not significantly different from crossbred Brown Swiss cows in this regard, the overall average values being 661.76±34.74 and 656 91±44.45 Kcal respectively for the two groups.

The average gross energy consumption (Mcal) per kg of FCM produced by crossbred Jersey and crossbred Brown Swiss cows also did not differ significantly as evident from the summarised data on fortnightly consumption of gross energy per kg FCM produced and the statistical analysis thereof given in Table 95, the overall averages being 5.76±0.23 and 5.87±0.25 Mcal respectively per kg of FCM produced by the two groups.

It will be evident from Table 96 that crossbred Jersey cows did not differ significantly from crossbred Brown Swiss cows with regard to the percentage of total gross energy consumed that is converted into milk energy, the overall average percentage being 13.37±0.54 in the former as against 13.07±0.52 in the latter.

c) Total digestible nutrients.

From the summarised data on fortnightly TDN consumption of crossbred Jersey and crossbred Brown Swiss cows and the statistical analysis of the same presented in Table 97 and Figs. 15 and 22, it can be seen that the overall average fortnightly consumptions of TDN were 82 29±3.01 and 83.07±3.92 kg respectively by the two groups of cows with overall average daily consumptions of 5.88 and 5.93 kg respectively.

It can be seen from the summarised data on fortnightly consumption of TDN per kg of FCM produced and the statistical analysis thereof given in

Table 98 that while cows in crossbred Jersey group consumed on an average 0.76±0.03 kg of TDN per kg of FCM produced, those in crossbred Brown Swiss group consumed on an average 0.77±0.03 kg of TDN per kg of FCM, there being no statistically significant difference between the two groups.

The average TDN consumption of 6.49 and 6 27 kg per day and 697 and 712 g per kg of FCM, reported by Pradhan et al. (1975) in the case of cross-bred Jersey and crossbred Brown Swiss cows respectively are essentially in keeping with the results obtained during the course of the present study, the minor variations being attributable to the comparatively higher body weights of (325.0 and 395.4 kg) animals used in their study.

Singh et al. (1976) reported an average daily TDN consumption of 8.04±0.21 kg in the case of Holstein x Hariana crossbred milch cows weighing on an average 418.40±11.98 kg and giving 10.15±0.56 kg of FCM per day which corresponds to a TDN consumption of 792 g per kg of FCM produced. Sharma et al. (1976) reported an average daily TDN consumption of 8.62 kg in cross-bred cows weighing on an average 340 kg and giving 12.99 kg of milk per day with an average TDN consumption of 640 g per kg of FCM. Singh et al. (1977) reported average TDN consumptions of 656 g and 832 g respectively per kg of FCM produced by half breds of Jersey x Hariana and Brown Swiss x Hariana cows.

d) Digestible energy.

The summarised data on fortnightly consumption of digestible energy by the two groups of crossbred cows and the statistical analysis of the same given in Table 99 and Figs. 16 and 22 show that while crossbred Jersey cows consumed on an average 344 47±12.82 Mcal, crossbred Brown Swiss cows consumed on an average 351.82±17.12 Mcal, there being no statistically significant difference between the two groups in this regard.

It can be seen from the data summarised in Table 100 that while crossbred Jersey cows consumed on an average 366.68±19.27 Kcal of digestible energy per $W^{0.75}_{kg}$, the crossbred Brown Swiss cows consumed on an average 368.10± 24.68 Kcal of digestible energy and that there was no statistically significant difference between the two groups of milch cows in this respect.

The summarised data on average consumption of digestible energy per kg of FCM, given in Table 101 and the statistical analysis thereof indicate that while crossbred Jersey cows consumed on an average 3.17±0.13 Mcal of digestible energy per kg of FCM produced, those belonging to the crossbred Brown Swiss group consumed on an average 3.28±0.14 Mcal of digestible energy per kg of FCM produced, there being no statistically significant difference between the two groups in this respect.

From the data on the efficiency of conversion of digestible energy into milk energy summarised in Table 102, it can be observed that while cows belonging to the crossbred Jersey group converted on an average 24 03±0.93 per cent of the total digestible energy consumed by them into milk energy, those belonging to the crossbred Brown Swiss group converted 23.40±0.91 per cent of digestible energy consumed by them into milk energy and that there was no statistically significant difference between the two crossbred groups in this regard.

Raina *et al.*(1975) reported an average daily consumption of 34.51±1.049 Mcal of digestible energy in crossbred Brown Swiss x Sahiwal cows giving on an average 13.50±0.24 kg of FCM per day with an average consumption of 2.56 Mcal per kg of FCM as against 34.13 and 3.55 Mcal respectively in Sahiwal cows with an average daily milk yield of 9.62 kg. The comparatively higher consumption of digestible energy per kg of FCM produced by the animals in the present study is evidently on account of the comparatively lower level of milk production as the efficiency of milk production of a given cow is dependent on her milk production level (Brody, 1968).

e) Crude protein.

It can be noted from the summarised data presented in Table 103 and Figs. 17 and 22 that cows belonging to the crossbred Jersey group consumed on an average 18.36±0.80, 18.90±0.85 and 18.47±0.64 kg respectively of crude protein during the 1st, 7th and 13th fortnights with average daily consumptions of 1.31, 1.35 and 1.32 kg respectively and those in crossbred Brown Swiss group consumed on an average 18.54±0.83, 19.32+0.89 and 18.74±1.23 kg with average daily consumptions of 1.32, 1.38, 1.34 kg respectively during the same fortnights. The analysis of covariance of fortnightly data on intake of crude protein by the two groups of crossbred cows, taking the data for the first fortnight as the concomitant variable showed that they did not differ significantly in this respect during any of the fortnights except during the 2nd fortnight when the average crude protein intake of crossbred Jersey (17.94±0.78 kg) was significantly higher ($P < 0.05$) than that of crossbred Brown Swiss cows (17.84±0.81 kg). The analysis of covariance in respect of last fortnight is given in Table 104.

From the data on average daily crude protein consumption per $W^{0.75}_{kg}$ summarised in Table 103 it can be seen that crossbred Jersey cows consumed on an average 19.98 ± 1.16, 20.12 ± 1.19 and 19.20 ± 1.00 g crude protein per $W^{0.75}_{kg}$ per day during the 1st, 7th and 13th fortnights respectively compared to 19.93 ± 1.28, 20.17 ± 1.33 and 19.12 ± 1.67 g respectively by the crossbred Brown Swiss cows during the same fortnights. The analysis of covariance of fortnightly data on average daily crude protein consumption per $W^{0.75}_{kg}$ taking the values in respect of first fortnight as concomitant variable showed that the two crossbred groups did not differ significantly in this regard throughout the experimental period of 13 fortnights except during the 2nd fortnight when crossbred Jersey cows consumed (19.50 ± 1.15 g) significantly more crude protein per $W^{0.75}_{kg}$ ($P \angle 0.05$) than crossbred Brown Swiss cows (19.07 ± 1.20 g). The analysis of covariance of data for the 13th fortnight is given in Table 105.

It will be evident from the summarised data presented in Table 103 that crossbred Jersey cows consumed on an average 0.160 ± 0.008, 0.166 ± 0.006 and 0.181 ± 0.015 kg of crude protein per kg of FCM produced during the 1st, 7th and 13th fortnights respectively as compared to 0.178 ± 0.009, 0.179 ± 0.009 and 0.181 ± 0.009 kg of crude protein respectively for the production of one kg of FCM by crossbred Brown Swiss cows during the same fortnights. The analysis of covariance of fortnightly data on average crude protein consumption for the production of one kg of FCM by the two groups of cows, taking the data for the first fortnight as the concomitant variable showed that they did not differ significantly in this regard during any of the 13 fortnights. The analysis of covariance in respect of 13th fortnight is presented in Table 106.

Raina et al. (1975) reported an average daily crude protein consumption of 2 19±0.082 and 2.167±0.083 kg respectively in the case of Brown Swiss x Sahiwal crossbreds and Sahiwals giving on an average 13.50±0.24 and 9.62±0.30 kg respectively of milk daily. The comparatively lower crude protein intakes of animals in the present study can be attributed to the comparatively lower level of milk production in the animals. However, the average crude protein intakes of 162 and 226 g per kg FCM produced by crossbred Brown Swiss and Sahiwal cows respectively reported by these authors are reasonably comparable with the values obtained in the present study. Sharma et al. (1976) also reported an average daily crude protein consumption of 2.19 kg in Brown Swiss x Sahiwal crossbreds producing 12.99 kg of milk daily.

f) Digestible crude protein.

From the summarised data on fortnightly intake of digestible crude protein by the two groups of cows and the statistical analysis thereof given in Table 107 and Figs. 18 and 22, it can be seen that while animals in the cross bred Jersey group consumed on an average 11.12±0.51 kg of DCP, those in crossbred Brown Swiss group consumed on an average 11.32±0.56 kg DCP, there being no statistically significant difference between the two groups of milch cows in this respect.

It can be seen from the summarised data on average daily intake of digestible crude protein (g) per $W_{kg}^{0.75}$ and the statistical analysis of the same presented in Table 108 that the crossbred Jersey cows consumed on an average 11.91±0.65 g of digestible crude protein daily per $W_{kg}^{0.75}$ as against the average daily consumption of 11.83±0 83 g of digestible crude protein per $W_{kg}^{0.75}$ in the case of crossbred Brown Swiss cows. It can also be seen from Table 108 that the two groups did not differ significantly in this respect.

The summarised data on average DCP consumption per kg of FCM produced by crossbred Jersey and crossbred Brown Swiss cows and the statistical analysis of the same presented in Table 109 show that they consumed on an average 103.45 ± 4.60 and 104.98 ± 4.60 g respectively of digestible crude protein per kg of FCM produced, the mean difference between the two groups being not statistically significant.

Pradhan *et al.* (1975) reported average daily consumptions of 0.776 and 0.710 kg of DCP respectively by crossbred Jersey and crossbred Brown Swiss cows giving on an average 9.3 ± 0.42 and 8.80 ± 0.77 kg respectively of FCM per day. The average daily intake of 0.794 and 0.809 kg of DCP by crossbred Jersey and crossbred Brown Swiss cows respectively in the present study are slightly higher than those reported by Pradhan *et al* (1975). However, the average daily DCP consumptions of 0.795, 0.753 and 0.794 kg respectively in the case of crossbred Jersey, crossbred Brown Swiss and crossbred Holstein cows reported by Singh *et al.* (1977) are comparable with those of animals in the present study. According to them, the daily DCP consumptions by Holstein Jersey and Brown Swiss crosses were almost the same, eventhough the DCP consumptions per day over maintenance by Jersey crosses were higher than those of others. However, they reported that the DCP consumption per kg of FCM was lowest in the Jersey crosses followed by Holstein and highest in Brown Swiss, thereby indicating that Jersey crosses were more efficient converters of feed (protein) into milk (protein) than the other two crosses. The average DCP consumptions ranging from 9.523±1.629 to 10.198±1.741 g per $W_{kg}^{0.75}$ reported by Kakkar and Mudgal (1978) in the case of lactating Sahiwal cows are comparable with those of animals in the present study.

g) Nitrogen balance and efficiency of utilisation of nitrogen.

The average intake of nitrogen and its outgo through urine, dung and milk and the balance thereof along with statistical analysis are presented in Table 110. It can be seen that there is no significant difference between crossbred Jersey and crossbred Brown Swiss cows in respect of nitrogen balance, both the groups being at a marginally positive balance of 4.02±1.08 and 5 23±0.79 g per day respectively during the trial. In both the groups, the nitrogen excretion through urine was comparatively more than that in the faeces. This is in keeping with the observations of Kakkar and Mudgal (1978). Further, the secretion of nitrogen into milk was the minimum when expressed as a percentage of total outgo. The total intake as well as total outgo of Nitrogen was similar in both the groups. The per cent values of total nitrogen retained are 1.57 for crossbred Jersey and 2.44 in crossbred Brown Swiss cows. These results are essentially in keeping with the observations of Kakkar and Mudgal (1978) who reported an average daily balance of 2 61±4.21, 2.79±4.59, 1.41±3.23 and 1.00±3.37 respectively for four different groups of Sahiwal cows fed as per N.R.C. Standard.

It can be seen from Table 110 that the total nitrogen retained expressed as a percentage of total intake as well as, as a percentage of total absorbed, also do not differ significantly, the overall mean percentages being 18 19±1.21 and

30.35±2.38 respectively for crossbred Jersey and 19.77±0.86 and 32.98±1.33 respectively for crossbred Brown Swiss cows. It can be seen that while the former secreted 27 16±2.68 per cent of absorbed nitrogen in their milk the latter secreted 28.86±1.59 per cent, there being no significant difference between the two groups. Both the genetic groups do not seem to differ significantly in respect of the percentage of consumed nitrogen retained in tissues, the average values for crossbred Jersey and crossbred Brown Swiss cows being 1.57±0.40 and 2.44±0.36 respectively.

The values obtained for various measures of efficiencyof utilisation of Nitrogen in the present study are comparable with those reported by Kakkar and Mudgal (1978) in the case of lactating dairy cows except in respect of total nitrogen retained in tissues and milk together.

5.2.10. Economic efficiency.

a) Income over feed cost.

From the fortnightly data on feed cost and their statistical analysis presented in Table 111 and Figs 19 and 22, it can be observed that the average fortnightly feed cost of crossbred Jersey and crossbred Brown Swiss cows are not significantly different from each other, the overall average fortnightly feed cost being Rs 239.82±9.54 with a daily average of Rs 17.13 in respect of the former compared to Rs 245.15±12.09 and Rs 17.51 respectively in the case of the latter. Similarly, it can be seen from Table 112 and Figs.20 and 22 that the two crossbred groups of cows do not differ significantly in respect of the average fortnightly income from milk, the overall mean fortnightly income being Rs 548.74±20.68 with an average daily income of Rs 39.20 in the case of crossbred Jersey as against average fortnightly income of Rs 547 69±29.40 with average daily income of 39.12 in the case of crossbred Brown Swiss cows Further, it can be seen from Table 113 and Figs. 21 and 22 that both cross bred Jersey and crossbred Brown Swiss cows are statistically similar in respect of the fortnightly income over their feed cost, the overall average fort nightly income being Rs 308.92±18.68 in the former and Rs 302 15±23 33 in the latter, the average daily income being Rs 22.07 and Rs 21 58 respectively.

b) Dairy merit.

The fortnightly data on dairy merit and the statistical analysis thereof presented in Table 114 indicate that there is no significant difference between the groups of crossbred Jersey and crossbred Brown Swiss cows, the overall average values being 22.74±0.88 and 22.59±0.89 respectively for the two groups.

Jadhav and Bhatnagar (1983) reported highly significant differences among half breds of Holstein x Tharparkar, Holstein x Sahiwal, Brown Swiss x Sahiwal, Jersey x Tharparkar and Brown Swiss x Tharparkar in respect of their lactation dairy merit. They observed significantly higher dairy merit of 28.82±0.25 in Holstein x Tharparkar cows compared to 26.59±0.14 and 26.01±0.14 respectively in Brown Swiss x Sahiwal and Brown Swiss x Tharparkar and 26.20±0.33 in Jersey x Tharparkar cows, there being no significant difference between Brown Swiss and Jersey crosses as is observed in the present study. According to them, selection on the basis of dairy merit may be advantageous over that based on absolute milk yield because it takes into consideration the general adaptability, inherent capacity for milk production and efficiency of feed utilisation. They found that cows born to Holstein sires had higher body weight and higher dairy merit compared to those born to Jersey sires, having lower body weight and lower dairy merit, thereby indicating that it may be profitable if attention is focussed to body size while selecting cows on dairy merit.

According to Brody (1968), the upper limiting value of dairy merit ratio is 50 per cent as not more than half of the TDN energy can be converted into milk energy. According to him, superior dairy animals convert about one-third of the total consumedTDN energy into milk energy, good dairy animals about one-fourth and a 25 per cent dairy merit level pays, approximately, for the dairy man's work, feed and other expenses at the current rate. Really profitable milk production, however, involves higher dairy merit.

The comparatively lower dairy merit ratios obtained for crossbred Jersey as well as crossbred Brown Swiss cows in the present study, however, is partly on account of assigning a higher calorific value of 4400 Kcal per kg of TDN as recommended by Maynard et al. (1979) in the computation of dairy merit in the present study as against 3999 Kcal used by Jadhav and Bhatnagar (1983) as per the original formula suggested by Brody (1968) and partly because of the lower level of milk production of animals in the present study compared to Sahiwal and Tharparkar crosses of Brown Swiss and Jersey, used by the above workers Sharma et al. (1976) reported gross energetic efficiency of 20.8, 27.54 and 28.62 respectively for Tharparkar, Sahiwal and

Brown Swiss x Sahiwal crosses The gross efficiency of both crossbred Jersey and crossbred Brown Swiss cows in the present study are, however, higher than that of Sahiwal cows but lower than that of their crossbreds with Brown Swiss and Jersey.

SUMMARY

SUMMARY

An investigation involving a growth study and a lactation study was carried out with a view to compare the feed conversion efficiencies of crossbred Jersey and crossbred Brown Swiss cattle in respect of the two production functions.

Growth study was carried out on eight heifer calves of 5-11 months of age each belonging to the two genetic groups viz. crossbred Jersey and crossbred Brown Swiss for a total period of 28 fortnights under identical conditions of feeding and management. Individual records of daily intake of feed and water, fortnightly data on body weight, monthly data on body measurements and haematological values were maintained throughout the period of experiment. Two digestion cum balance-trials,one at the middle and the other at the end of the experimental period were carried out to find out the digestion coefficients of nutrients and efficiency of their utilisation from the feed. The feed conversion efficiency was assessed in terms of efficiency of utilisation of dry matter, gross energy, total digestible nutrients, digestible energy, crude protein, digestible crude protein and nitrogen for growth.

Lactation study was carried out on two groups of six lactating half bred Jersey and half bred Brown Swiss cows each, of almost similar age, parity, stage of lactation and level of production for a period of 13 fortnights under identical conditions of feeding and management Individual records of daily feed intake and milk yield and fortnightly data on body weight,

haematological values and milk composition were maintained throughout the period of study. A digestion-cum balance trial was carried out during the 11th fortnight to find out the digestion coefficients of nutrients and efficiency of nutrient utilisation from the feed. The biological efficiency of utilisation of feed for milk production was evaluated in terms of efficiency of utilisation of dry matter, gross energy, total digestible nutrients, digestible energy, crude protein, digestible crude protein and nitrogen and the economic efficiency was assessed in terms of income over feed cost as well as dairy merit.

From the overall results obtained the following inferences were drawn.

1. Crossbred Jersey and crossbred Brown Swiss heifer calves showed an average daily weight gain of 356.6 and 329.9 g respectively during the entire period of 28 fortnights, there being no significant difference between the two groups in this respect.
2. No statistically significant difference was observed between the two genetic groups in respect of their body size as adjudged in terms of various body measurements, viz. height at the bottom of chest, top of withers and top of rump; girth at the region of chest, paunch and flank and linear measurements in terms of distance between pin bones, shoulder points, from point of shoulder to the pin bones and from external angle of ileum to hip point.
3. Crossbred Jersey and crossbred Brown Swiss heifer calves consumed on an average 3.26 ± 0.05 and 3.33 ± 0.12 kg respectively of dry matter per

day per 100 kg body weight during the entire period of 28 fortnights without showing any significant difference between them in this respect

4 There was no significant difference between crossbred Jersey and crossbred Brown Swiss heifer calves in respect of their average water consumption of 14 82 and 13.90 kg respectively per day

5. The haematological values in respect of both the groups showed no significant difference and the values were within the reported normal range indicating that all animals were in good nutritional status

6. The two genetic groups of heifer calves did not differ significantly in respect of their ability to digest various nutrients in their ration except that during digestion trial I, the average digestion coefficient of crude fibre was significantly higher (P /0.01) in crossbred Brown Swiss (62.27±1.12) compared to crossbred Jersey (55.68_1 28).

7 The average consumptions of 108.08±0.84 g, 442 40±3.59 Kcal, 65 50_0 50 g, 295.37±2.37 Kcal, 14.86±0.14 g and 9.08±0.09 g respectively of dry matter, gross energy, total digestible nutrients, digestible energy crude protein and DCP per $W^{0.75}_{kg}$, obtained in the case of crossbred Jersey were not significantly different from those of 107 19±2.24 g, 442 42±8.50 Kcal, 65 80±1.30 g, 295 52±5 71 Kcal 14.72_0 27 g and 9 00±0 16 g respectively obtained in the case of crossbred Brown Swiss heifer calves

8. The efficiency of utilisation of feed for growth in terms of quantities of dry matter, gross energy, total digestible nutrients, digestible energy,

crude protein and digestible crude protein needed per kg body weight gain in crossbred Jersey viz. 13.70±1.01 kg, 54.25±3.13 Mcal, 8.09±0.46 kg, 36.32±2.09 Mcal, 1.83±0.10 kg and 1.10±0.06 kg respectively were not significantly different from the average values of 14.80±1.06 kg, 61.47±4.47 Mcal, 9.17±0.68 kg, 41.19±3.00 Mcal, 2.03±0.14 kg and 1 24±0.08 kg respectively in the case of crossbred Brown Swiss heifer calves.

9. There was no significant difference between crossbred Jersey and crossbred Brown Swiss heifer calves in regard to their efficiency of utilisation of dietary protein for promoting growth as adjudged by nitro gen balance in g per day, the average values being 18 48±0.61 and 18.06±1.02 g respectively in digestion trial I and 17.90±1.02 and 18.86±1.15 g respectively in digestion trial II for the two groups.

10. Milch cows belonging to both the genetic groups not only maintained their body weight but also showed an overall average fortnightly weight gain of 1.44±0.14 and 1.71±0.06 kg respectively, there being no statistically significant difference between them in this regard.

11. The haematological values obtained in respect of both the genetic groups were within the reported normal range, suggesting that all experimental animals were in good nutriture.

12. There was no significant difference between crossbred Jersey and crossbred Brown Swiss cows in regard to the digestion coefficients of dry matter, crude protein, ether extract, crude fibre and nitrogen

free extract. Cows belonging to both the genetic groups maintained a marginally positive nitrogen balance without any significant difference in the mean values, indicating that all animals were in good nutritional status.

13. The two groups of crossbred milch cows did not differ significantly in respect of their feed consumption, the average daily intake of dry matter in kg per 100 kg body weight during the 1st, 7th and 13th fortnights being 3.92 ± 0.22, 4.01 ± 0.26 and 3.90 ± 0.23 respectively in the case of crossbred Jersey and 3.90 ± 0.29, 3.98 ± 0.30 and 3.87 ± 0.34 respectively in the case of crossbred Brown Swiss cows.

14. The average daily milk yield of 7.28, 7.06 and 6.43 kg respectively obtained during the 1st, 7th and 13th fortnights in the case of crossbred Jersey cows were not significantly different from those of 7.07, 7.08 and 6.80 kg respectively in the case of crossbred Brown Swiss cows.

15. The two groups of crossbred cows did not differ significantly in respect of their milk composition throughout the experimental period of 13 fortnights except during the 6th fortnight when the milk produced by crossbred Jersey had significantly higher content of total solids and fat ($P < 0.05$) than that of crossbred Brown Swiss cows.

16. Cows in the crossbred Jersey group did not differ significantly from those in the crossbred Brown Swiss group in respect of their fortnightly yields of butter fat, total milk solids, fat corrected milk and solids corrected milk.

17 The average daily consumptions of 158.13±8 17, 162 88±9 50 and 159 75_8 33g of DM and 19.98±1 16, 20.12±1 19 and 19.20±1 00 g of crude protein respectively per $W^{0\ 75}_{kg}$ during the 1st, 7th and 13th fort nights in the case of crossbred Jersey were not significantly different from the average consumptions of 157 58±9 86, 162 43±10 48 and 159 23± 12.37 g of DM and 19.93±1.28, 20 17±1.33 and 19 12±1.67 g of crude protein respectively in the case of crossbred Brown Swiss cows. Simiarly the overall average daily consumptions of 661.76±34 74 Kcal of gross energy 366.68±19.27 Kcal of digestible energy and 11.91±0.65 g of DCP per $W^{0.75}_{kg}$ in the case of crossbred Jersey were not significantly different from the average consumptions of 656.91±44.45 Kcal of gross energy, 368.10±24.68 Kcal of digestible energy and 11.83_0.83 g of DCP respectively in the case of crossbred Brown Swiss cows.

18. The efficiency of utilisation of feed for milk production in terms of gross energy total digestible nutrients, digestible energy and digestible crude protein needed for the production of one kg of FCM including the maintenance requirements in the case of crossbred Jersey were not significantly different from those values obtained in the case of crossbred Brown Swiss cows, the overall averages being 5 76±0.23 Mcal, 0.76±0.03 kg, 3.17±0.13 Mcal and 103 45±4.60 g respectively for the former and 5 87±0.25 Mcal, 0.77±0 03 kg, 3 28±0.14 Mcal and 104.98±4 60 g respectively for the latter Similarly the average daily consumptions of 1.27±0 06, 1 35±0. 05

and 1.50±0 12 kg ofDM and 0.16±0.008, 0.166±0.006 and 0.181±0.015 kg of crude protein respectively per kg of FCM produced, during the 1st. 7th and 13th fortnights in the case of crossbred Jersey cows were not significantly different from 1.41±0.07, 1.44±0.07 and 1.52±0.08 kg of DM and 0.178±0.009, 0.179±0.009 and 0.181±0.009 kg crude protein respectively in the case of crossbred Brown Swiss cows.

19. The economic efficiency assessed in terms of income over feed cost and dairy merit in respect of crossbred Jersey cows was not significantly different from that of crossbred Brown Swiss cows, the average values being Rs 22.07 per day and 22.74±0.88 respectively for the former and Rs 21.58 per day and 22.59±0.89 respectively for the latter.

The significance of the above inferences are discussed briefly.

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ABSTRACT

COMPARATIVE FEED EFFICIENCY OF CROSSBRED JERSEY AND CROSSBRED BROWN SWISS CATTLE

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ABSTRACT OF A THESIS
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ABSTRACT

A comparative evaluation of the feed conversion efficiencies of crossbred Jersey and crossbred Brown Swiss cattle of Kerala involving a growth study and a lactation study using eight heifer calves and six milch cows each for 28 and 14 fortnights respectively were carried out. While records of daily feed intake water consumption, fortnightly data on body weight, body measurements and monthly data on haematological values were maintained during the growth study, data on daily feed intake milk yield, fortnightly data on composition of milk, body weight and haematolo gical values were gathered during the lactation study. Digestion cum-balance trials were carried out during the 14th and 28th fortnights respectively under growth study and during the 11th fortnight under lactation study

There were no significant differences between crossbred Jersey and crossbred Brown Swiss heifer calves in respect of their average daily dry matter and water consumptions, various body measurements, haematological values and digestion coefficients of various nutrients in their feed throughou the experimental period of 28 fortnights except that the average digestion coefficients of crude fibre in crossbred Brown Swiss heifer calves during digestion trial I was significantly higher (P /0.01) than that of crossbred Jersey Both the groups of heifer calves did not differ significantly in respect of their average daily consumptions of dry matter, gross energy total digestible nutrients, digestible energy crude protein and digestible

crude protein per unit metabolic body size ($W_{kg}^{0.75}$). The feed conversion efficiency values as adjudged in terms of quantities of dry matter, gross energy, total digestible nutrients, digestible energy, crude protein and digestible crude protein needed per kg body weight gain in crossbred Jersey were 13.70±1.01 kg, 54.25±3.13 Mcal, 8.09±0.46 kg, 36.32±2.09 Mcal, 1.83±0.10 kg and 1.10±0.06 kg respectively and the same were not significantly different from the average values of 14.80±1.06 kg, 61.47±4.47 Mcal, 9.17±0.68 kg, 41.19±3.00 Mcal, 2.03±0.14 kg and 1.24±0.08 kg respectively observed in the case of crossbred Brown Swiss heifer calves. Both the groups did not differ significantly in respect of average daily nitrogen retention of 18.48±0.61 and 18.06±1.02 g respectively during trial I and 17.90±1.02 and 18.86±1.15 g respectively during trial II.

Milch cows belonging to both the genetic groups of crossbred Jersey and crossbred Brown Swiss not only maintained their body weight but also showed an overall average fortnightly weight gain of 1.44±0.14 and 1.71±0.06 kg respectively without any significant difference between them in this regard. They also failed to show any significant difference in respect of feed consumption, digestion coefficients of nutrients and nitrogen retention, the marginally positive nitrogen balance together with normal haematological values obtained in respect of both the groups indicated that all the animals were in good nutritional status. The average daily milk yields of 7.28, 7.06 and 6.43 kg respectively during the 1st, 7th and 13th fortnights in the case of crossbred Jersey cows were not significantly different from those of 7.07, 7.08 and 6.80 kg respectively in the case of crossbred Brown Swiss cows There was no significant difference between cows belonging to the two genetic groups in respect of their average daily consumption of DM, gross energy, TDN, crude protein and DCP per unit metabolic body size. The overall average consumptions of 5.76±0.23 Mcal, 0.76±0.03 kg, 3.17±0.13 Mcal and 103.45±4.60 g respectively of gross energy, total digestible nutrients, digestible energyand DCP per kg of FCM produced by crossbred Jersey cows including their maintenance requirements were not significantly different from 5.87±0.25 Mcal, 0.77±0.03 kg, 3.28±0.14 Mcal and 104.98±4.60 g respectively of the same by crossbred Brown Swiss cows. The two crossbred groups of milch cows failed to show any significant difference in respect of their economic efficiency in terms of dairy merit as well as income over feed cost, the average values being 22.74±0.88 and Rs 39.20 per day for crossbred Jersey and 22.59±0.89 and Rs 39.12 per day for crossbred Brown Swiss cows respectively.

No significant differences were observed in the performances of crossbred Jersey and crossbred Brown Swiss cattle in respect of their growth and milk production when reared in the same locality under identical conditions of feeding and management.