A COMPARISON OF TWO WINTER MANAGEMENT SYSTEMS

FOR DRY DAIRY CATTLE

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ABSTRACT

Two management systems for dry dairy cows were studied during the winter of 1975 at No. 3 Dairy Unit, Massey University. The objective of the study was to help develop a system which may reduce the need for supplementation of pasture grown, and at the same time ensure that adequate feed supplies are available over the winter and early spring to meet animal requirements.

The parameters studied were pasture growth rates and recovery, pasture damage through pugging, feed consumption and live weight changes of cows, milk production for the first three months of lactation, and the grass 'cover' on the two farmlets.

In general, the results have shown that each system had its own advantages and disadvantages and these are discussed in the text. It is, however, recommended that while such advantages and disadvantages exist, a grazing system which incorporates the two systems warrants experimentation. In addition, better methods of measuring pasture growth rates and grass 'covers' deserve further investigation.

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CHAPTER 1

INTRODUCTION

The main New Zealand system of dairying (seasonal dairying) is unique in that it relies mainly on pasture and pasture products (hay and silage) as feed for cows throughout the year with little or no use of other feeds. The use of hay or silage and occasionally other forage supplements (for example chou mollier) during some seasons of the year is due to variation in pasture production associated with seasonal changes in climate.

Usually feed shortages are experienced in either winter - early spring or in the summer (Brougham, 1970a), while large surpluses of feed may be obtained in the spring and small surpluses in the late autumn. In New Zealand, the intake of energy is the commonest deficient nutrient in pasture and pasture products (Hutton, 1962), whereas proteins, minerals and vitamins are generally adequate.

The problem for the individual farmer is to make comparisons between the amount of pasture he is likely to have available for periods of shortages and the likely feed requirements of his stock. If this assessment can be made earlier rather than later, he can make changes to his management system or arrange to purchase additional feed so as to ensure that requirements are met.

In this thesis some of the problems associated with meeting the requirements of pregnant cows during the winter period have been studied. The project was undertaken on the Massey University No. 3 Dairy Unit, and involved a comparison of two alternative systems of wintering dairy cattle. The objectives of the study were to look into alternative systems which may help to reduce the need for supplementation of the pasture grown, and at the same time ensure that adequate feed supplies would be available over the winter and early spring to meet animal requirements.

Before the experimental methods, results and discussion of results are presented, the objectives of winter management of dairying on a seasonal dairy farm and the necessary knowledge to achieve these objectives are reviewed.

CHAPTER 2

REVIEW OF LITERATURE

It is noted in the introduction that feed supplies may be scarce during the winter season and early spring. Because of this, there has been a lot of attention devoted to planning the feeding of cows during this period so that cows do not calve in poor condition or calve when feed supplies are limited. Underfeeding before and after calving is reported to reduce milk production (Hutton, 1968; Patchell, 1957; Campbell and Flux, 1948 and others).

This review aims at examining the objectives of wintering dairy cows on a seasonal dairy farm and the necessary knowledge required to achieve these objectives.

2:1 Objectives of Wintering Dairy Cows on a Seasonal Dairy Farm

There are two main objectives of wintering dairy cows, namely:

(a) To ensure that cows calve in satisfactory condition.
(b) To ensure that enough feed is available in early lactation.

(a) Research work here in New Zealand has shown that underfeeding of cows during the dry period lowers subsequent milk production (Flux, 1950, 1957; Hutton and Parker, 1973; Patchell, 1957 etc.). Wallace (1958) reporting the results of an experiment on the use of autumn saved pasture for cows in the last six to eight weeks before calving concluded that provided cows are in good condition at the time of drying off and provided also that they can be well fed from the time of calving onward, there is very little to be gained from feeding them more than moderately well during the last six to eight weeks before calving. Broster (1971, 1972) has done extensive reviews of the level of feeding before and after calving. Most of the work he cited, in which cows were underfed, report the loss of production from cows. It is therefore pertinent that cows should be fed so that they calve in at least moderate condition.

(b) Adequate availability of feed in early lactation.

A number of research workers have noted that cows' requirements increase in early lactation (Wallace, 1961; Hutton, 1962, 1971 and others). At this time cows need as much high quality feed (leafy pasture) as they can eat (Davey, 1974). Davey (1974) suggests that maximum peak yields can be obtained only by lenient grazing so that feed consumption is at a maximum. Thus, on a highly stocked farm to have enough feed in early lactation, it is necessary to restrict cows intake during the dry period. In this way wastage of feed by overfeeding may be avoided, and also wastage by treading and fouling may be minimized by utilizing a high proportion of the grown feed. At high stocking rates, however, pasture damage by treading reduces pasture yield (Edmonds work 1958-1970; Campbell, 1966).

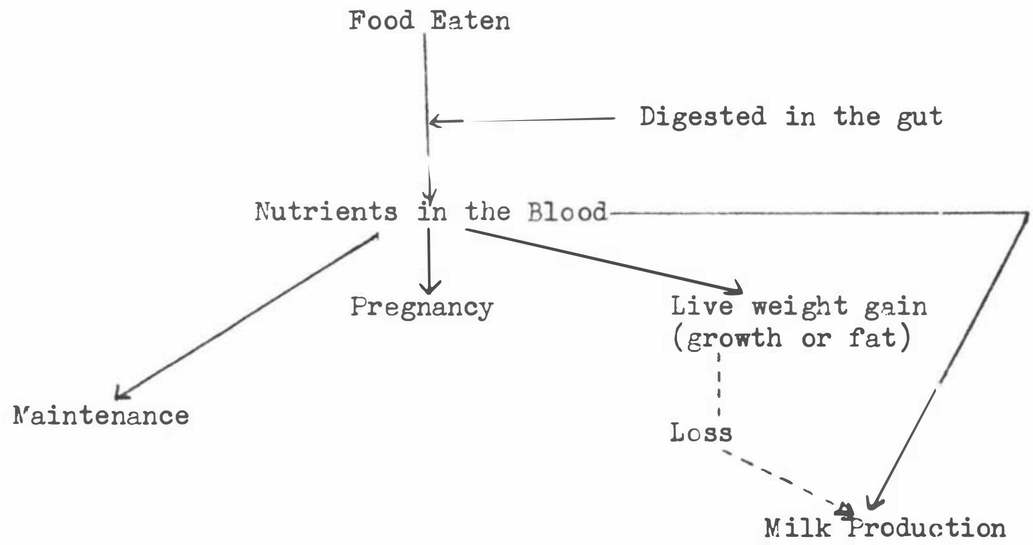
In order to achieve the above objectives, a knowledge of the following is necessary: Cow requirements; Factors affecting grass production; Methods used to assess the amount of feed on hand; and the Wintering systems available. These factors are reviewed.

2:2 Cows' Requirements

The feed requirements of a cow are arbitrarily divided into those for maintenance and those for production. The maintenance requirement is the amount of food that will cause the animal to maintain a steady weight (Davey, 1970). The maintenance ration should provide for the following nutrients: energy, proteins, minerals, vitamins and water. Feed in excess of maintenance requirements is used for production. Production here refers to growth (heifers), live weight gains, pregnancy and milk production.

Figure 2.1 shows the way food is partitioned to various functions in a dairy cow.

Figure 2.1 - Partitioning of Nutrients in a Dairy Cows (after Davey, 1970).



During the dry period (when cows are not lactating), the cows have to eat in order to maintain normal body functions and live weight, and any extra feed goes for pregnancy and some live weight gain. Evidence suggests that it is preferable for cows to gain in body weight during pregnancy so that they may calve in 'reasonable' condition (Reviews by Broster, 1971 and 1972). Cows which maintain their weight or those which gain weight, lose it in early lactation. The cows which are underfed may not lose weight in early lactation, but milk production is low (Broster, 1971). Flux (1950) compared two levels of feeding with six pairs of 2-year identical twin heifers and found that those which had been well fed before calving produced more milk than their sisters which had been poorly fed.

Since cows lose weight in early lactation because they cannot eat as much food as they require for milk production, a knowledge of their requirements in relation to predicted performance is necessary.

The feeding standards for various classes of livestock have been published by the Agricultural Research Council (ARC, 1965), National Research Council (NRC, 1971) and other authorities. These standards are taken as guides only for feeding stock since they vary considerably due to errors of estimate, prediction and the various inaccuracies inherent in all systems used to estimate the requirements (Bryant, 1971). Usually the requirements are expressed in the same terms as are used for assessing feed values, e.g. Digestible Organic Matter (DOM), Digestible Dry Matter (DDM), Total Digestible Nutrients (TDN), Starch Equivalent (SE), Digestible Energy (DE), Metabolizable Energy (ME), and Net Energy (NE). The universally accepted term now is the ME system, although the other terms are used occasionally.

Energy and proteins are the main nutrients of concern in animal production in many countries of the world. In New Zealand, however, pasture herbage contains an abundance of protein so that interest is generally restricted to energy fraction of the diet (Hutton, 1962). Bryant (1971) stated that nutrients other than energy generally become of practical significance only when the amounts fall below a minimum level. Thus, the energy requirements of dairy cows for maintenance and production are reviewed.

2:2:1 Energy Requirements for Maintenance

Hutton (1962) reported the results of three trials each lasting four months, on the maintenance requirements of dairy cattle in New Zealand. In the three trials: (1) Restricted dry cows (dry cows fed to constant live weight); (2) Fully fed dry cows; and (3) Fully fed lactating cows, he found that the restricted cows (average weight 744 lb = 338 kg) required approximately 8 lb DM as grass (3.64 kg) per cow for maintenance and the fully fed dry cows (average weight 927 lb = 421.4 kg) required 19 lb DM as grass (8.64 kg) per cow/day, while the fully fed lactating cows (average weight about 780 lb = 354.5 kg) ate 29.0 lb DM as grass (13.2kg) on the average for maintenance and production. The fully fed dry group had more than 2.4 times the consumption of the dry restricted group. The fully fed lactating group had more than 3.6 times the consumption of the restricted group and 1.5 times the fully fed dry group. The digestibility of pasture varied between 80 - 72% in September and December respectively. If feed quality in September is 12.144 MJoules ME (2.9 Mcal ME)/kg DM (Hutton and Parker, 1973) and the maintenance requirements are taken as 3.64 kg DM/cow per day, this would mean an energy requirement of 44.183 MJ ME/day (10.56 Mcal ME). In December to supply the same amount of energy when the digestibility of the herbage is 72%, more grass has to be eaten. Thus $\frac{44.183}{10.83656}$ kg DM of grass would be required. The figure of 10.84 MJ is obtained by multiplying 4.4 x .72 x 0.82 x 4.184 — where .72 is the digestibility of pasture, 0.82 conversion factor from DE to ME; (4.4 x 4.184) MJ ME is gross energy of feed.

Davey (1970) gives a figure of 9 lb DOM (4.09 kg) for maintaining a cow weighing 800 lb (363.6 kg). If 1 kg DOM contains 3.8 Mcal ME, ie 15.8992 MJ (Hutton, 1971), then 9 lb DOM (4.09 kg) would contain 63.6 MJ ME required per day.

Other workers have worked out the maintenance and pregnancy requirements. For example, Jagusch (1973) has given the requirements of a Jersey and Friesian cow in relation to food quality as follows:

Requirements (MJ ME/day) for a pregnant non-lactating Cow

Breed of Cow	Feed Quality (grass)	Requirements Weeks from term		
		8 - 4	4 - 2	2 - 0
Jersey (360 kg)	10.878 MJ ME/kg DM (2.6 Mcal)	39.75 MJ ME (3.65 kg DM)	50.21 MJ ME (4.6 kg DM)	54.81 MJ ME (5.0 kg DM)
Friesian (500 kg)	10.878 MJ ME/kg DM (2.6 Mcal)	56.48 MJ ME (5.6 kg DM)	71.13 MJ ME (6.54 kg DM)	77.4 MJ ME (7.11 kg DM)

Hutton (1971) compared the results obtained for the dry cows under the grazing situation with those predicted by ARC (1965) and the United States Department of Agriculture (USDA, 1967) workers and he found that the maintenance and pregnancy requirements during this period were high, thus:

Hutton's Work 1971

Year	Dry Period in days	Mean Live Weight (kg)	Total Energy Consumed MJ ME	Energy Intake per $kg^{0.75}$ MJ ME/kg $LW^{0.75}$	ARC ARC 1965 MJ ME/kg $LW^{0.75}$	USDA USDA 1967 MJ ME/kg $LW^{0.75}$
1965-66	103	351	7531.2	0.908	0.51	0.585
1966-67	76	377	5230.0	0.812	0.51	0.585
1967-68	107	354	6066.8	0.690	0.51	0.585
	Mean = 95	Mean = 361	Mean = 6276.0			

Hutton suggested that some of the reasons for the high figures were:

(i) The dry cows were continuing to graze with the milking herd because the group was small to manage separately, and during this time the cows ate more than their maintenance ration.

(ii) The management practice used was on/off grazing which appeared to increase the errors of estimating faecal outputs with indigestible markers and this caused an upward bias in estimates of intake.

(iii) The estimates of the requirements derived from feeding tables have been under conditions of stall feeding or energy balance and therefore the figures obtained under grazing situation would be high due to increased energy expenditure. In practice, pregnant cattle are exposed to wind, rain and cold and this may necessitate an increase of about 20% in winter feed requirements. Hutton suggested that by taking into account the factors mentioned it is practicable to reduce the mean 95-day requirement from 6276 MJ ME to 5439.2 MJ ME. Of this 1255.2 MJ ME represents the requirements for foetal growth and increased metabolism of the pregnant cow. Thus 4184 MJ ME would be for maintenance for 95 days, i.e. $\frac{4184}{95}$ MJ ME/day = 44.042 MJ ME/day.

The National Research Council (NRC, 1971) had cows requirements worked out in relation to their weight. For example a 350 kg cow requires 42.26 MJ ME per day for maintenance; and for 450 kg cow the requirements for maintenance would be 51.46 MJ ME/day. If metabolic weights of cows are:

$350^{\frac{3}{4}}$ = 80.9 (81) kg M wt

$450^{\frac{3}{4}}$ = 97.7 kg M wt

then requirements for maintenance would be the same when expressed per unit metabolic weight, thus:

350 kg cow = 42.26/81 MJ ME/kg L wt$^{0.75}$/day = 0.522

450 kg cow = 51.46/97.7 MJ ME/kg L wt$^{0.75}$ day = 0.526

These figures seem to be comparable to Hutton's figures of 44.18 MJ ME/day for the restricted group (1962), and 44.04 MJ ME/day (1971) for a dry cow weighing on the average 361 kg, with an average dry period of 95 days. Davey, 1976 (Pers.Comm.) gave the latest figure for maintenance requirements of 0.55 MJ ME/kg L wt$^{0.75}$/day. This means, for a cow weighing 350 kg live weight (81 kg M wt), it will require 44.55 MJ ME/day.

Taking the digestibility of pasture to be 75 - 78% in winter (Davey, Pers. Comm., Hutton & Parker, 1973), and taking 1 kg DM of pasture to contain 18.41 MJ GE = 13.8 MJ DE and 11.297 MJ ME, the amount of pasture required for maintenance per day can be worked out from Hutton's figures of 44.18 MJ or 44.04 or from Davey's figure of 44.55 MJ ME/day respectively. This works out to be approximately 4 kg of pasture for a 350 kg cow.

2:2:2 Energy Requirements for Pregnancy

The energy for pregnancy is considered to be the energy stored in the calf, placenta, and ammiotic fluid and energy in the uterine increase (Brody, 1964). The energy is then computed from the components of dry matter, e.g. fat and protein, of calf, placenta and ammiotic fluid and uterine increase.

From Brody's book for Eckle's data, Dr A. Davey worked out the energy in the Jersey calf (22.3 kg or 49 lb) as follows:

Energy in calf	129.7 MJ NE (31 Mcal NE)
Energy in placenta and ammiotic fluid	37.66 MJ NE (9 Mcal NE)
Energy in the uterine	23.85 MJ NE (5.7 Mcal NE)
Total	191.21 MJ NE (45.7 Mcal NE)

Heat increment for pregnancy is about 228.3 Mcal = 955.2 MJ, thus the total energy = 274 Mcal ME or 1146.4 MJ ME. The ratio of the stored energy to total metabolizable energy required for pregnancy is approximately 1 : 6.

The NRC (1971) gives a figure of 3 Mcal ME/day (12.55 MJ ME per day) for a 350 kg cow as adequate to meet the total requirements of foetal and maternal development with no allowance for fattening during the last two months prior to calving. This would equal 0.155 MJ ME/kg L wt$^{0.75}$/day (i.e. $\frac{12.55}{81}$, 81 being the metabolic weight of the cow).

These are very small requirements as compared to maintenance requirements.

Hutton (1971) had total requirements for pregnancy of 300 Mcal ME = 1255.2 MJ ME for a grazing animal during an average dry period of 95 days. This would equal $\left(\frac{1255.2}{95 \times 81}\right)$ = 0.163 MJ ME/kg L wt$^{0.75}$/day. This compares favourably with NRC (1971) figure of 0.155 MJ ME per kg L wt$^{0.75}$ per day.

The ARC (1965) considers that the pregnancy requirements are covered by increasing the level of feeding above maintenance by 5% level three months pre-partum and making successively increases of 17% one month later, and of 45% and 50% in the last two fortnightly periods before calving. Taking the pregnancy increment to be 45% above maintenance and taking the maintenance requirements to be 44 MJ ME/cow/day, the pregnancy requirements would be 1188 MJ ME for the dry period.

If the average daily requirements for pregnancy are taken as 12.96 MJ ME (0.160 MJ ME/kg L wt$^{0.75}$/day) and assuming the pasture DM contains 11.3 MJ ME, then the amount of pasture required for pregnancy would be 1.15 kg DM per day for a 350 kg cow.

2:2:3 Weight of Cows before Calving

When pregnant cows increase in weight, it may be due entirely to products of concepta if cows maintain their own weight (Hutton & Parker, 1973). Liberal feeding at this time, however, may cause the animal itself to put on some weight in addition to weight of the concepta (Broster, 1971; Greenhalgh, 1969). This additional weight may contribute to milk production in early lactation.

The weight of the concepta may increase by 24 kg for a Jersey cow and 34 kg for a Holstein cow over the last 60 days of pregnancy (Greenhalgh, 1969). Patchell (1957) cited by Greenhalgh (1969) calculated the weight increase of the concepta in Jersey cows and he found that the concepta increased by about 30 kg during the last ten weeks of pregnancy. Wallace (1958) obtained similar weight increases (31.5 kg and 21.4 kg for the 100% and 85% groups respectively) in animals fed pasture over a period of five weeks.

Considering an average increase in weight of 30 kg for a period of sixty days (9 weeks), this would mean a gain of 0.5 kg per cow per day. If pregnant cows gain less than the amount shown, their own body weight is declining (maternal live weight). Thus provisionally any level of feeding during the dry period which leads to apparent loss in maternal live weight is underfeeding (Greenhalgh, 1969; Broster, 1971).

Hutton and Parker (1973) obtained a gain of 0.9 kg/cow/day for the last four weeks of pregnancy by feeding 4.8 kg pasture DM (1.4% live weight). This is about 25 kg gain for cows weighing 330 kg on the average. The cows which merely maintained live weight required 2.8 kg pasture DM equivalent to two-thirds the quantity eaten by the better fed twins.

From these results it seems that an extra 2 kg pasture per day (4.8 - 2.8) above maintenance was required to support pregnancy and some live weight gain. If 1.15 kg DM of pasture is required for pregnancy per day, then 0.85 kg DM of pasture is the amount available to the animal to put on weight. In energy terms, this would be about 9.60 MJ ME/day (pasture contains 11.3 MJ ME/kg DM).

Using the ARC (1965) estimates of the energy content of body gain for a 350 kg beef animal and assuming an efficiency of use of ME of 55%, it may be calculated that the requirements for 1 kg of live weight gain (L.W.G.) is approximately 2.5 kg DM as pasture. Hence 0.85 kg of DM/day during the dry period would be expected to support a body weight increase of nearly 0.34 kg/day.

Calculations

350 kg beef animal gaining at 1 kg/day deposits 3700 Kcal energy (3.7 Mcal ME OR 15.48 MJ ME).

Assume 55% efficiency of deposition	6.74 Mcal ME (28.2 MJ ME)
Pasture contains 11.3 MJ ME/kg DM	2.495 kg DM
	2.5 kg DM

2:2:4 Total Energy Requirements for Maintenance, Pregnancy and some Live Weight Gain

In practice the feed given to a cow would be covering maintenance, pregnancy, and some live weight gain since these requirements would have been estimated before the feed is given to the animal. The NRC (1971) estimated a figure of 54.4 MJ ME (13 Mcal) for maintenance and pregnancy for a cow weighing 350 kg. Jagusch (1973) has estimated the requirements for a Jersey and a Friesian cow (pg 7 in this review) depending on pasture quality. The requirements of a Jersey cow come up to 54.8 MJ ME/day two weeks prior to calving and the Friesian is 77.4 MJ ME/day. ARC estimated the requirements of a cow weighing 500 kg four weeks from term as 70.7 MJ ME per day. These requirements have no allowance for fattening.

If a 'standard' cow is taken as a Jersey weighing 350 kg then the average requirements during the dry period, assuming that some improvement in body condition is required (0.3 kg/day), would be as follows:

Function	Energy required/day MJ ME/day	Pasture equivalent assuming energy content of 11.3 MJ ME/kg DM of pasture (kg DM)
Maintenance	44.55	4.00 (see pg 9 in this review)
Pregnancy	12.96	1.15 (Hutton, 1971)
Body weight gain	9.60	0.85 (See pg 17)
total	67.11	6.00

Davey (1974 - Data No. 3 Dairy Unit) recommended that the feeding level should be progressively increased during pregnancy as follows:

Month	Average Live Weight	DM Intake (kg DM/day as pasture)
May	339	3.61
June	341	4.41
July	354	4.95
August	330	10.22

These requirements refer to cows calving in the July/August period. These data differ from the previous calculations in that the cows were slightly lower in body weight and no allowance was made for increasing body condition.

In the following section the factors which influence pasture production are reviewed.

2:3 Factors which Affect Grass Production

Pasture production follows a pattern which is largely dependent on the growth cycle of the plant (Line, 1963). Plant growth is subject to variations because of the climate and other environmental factors such as soil types, soil nutrients, diseases and pests of plants. Variations of such kind bring variations in pasture yield and nutritive value and hence animal production from pasture. The definitions of yield, nutritive value and feeding value (or quality) as they may apply are warranted.

Yield: The amount of dry matter produced per unit area in a given period, for example; daily, weekly, monthly or seasonally e.g. summer, autumn, winter and spring, or the whole year.

Nutritive value: It is a complex term since it may refer to a single characteristic or to collectively a large number of characteristics of a feedstuff including energy producing and protein forming constituents together with essential minerals, and vitamins necessary for health. In addition, the food should be free of potentially toxic substances that may be detrimental to the animal (Wilson, 1967). For the purpose of this review nutritive value (NV) will be taken to mean concentration of nutrients in a plant.

Feed value (or quality): This has been defined as a function of both intake and nutritive value which determine animal production from pasture (Ulyatt, 1970).

Maximum yields of pasture species are usually obtained when all the environmental factors are optimal (none is limiting). Under such conditions the pastures produce bulk (DM/ha) when they are allowed to grow without interruptions over considerable periods of time (Smetham, 1973). However, the yield increases up to a certain point with length of growing period, and this period during which yield increases differs for different species. Eventually yield either increases no further or may actually decrease. On the other hand, if pastures are grazed frequently, they may not reach flowering stage and the yield is also lowered. However in terms of nutrients present in such pastures, they may be in high concentrations unlike those in matured pastures.

In general the amount of grass grown will depend on such factors as climate, soils and management factors.

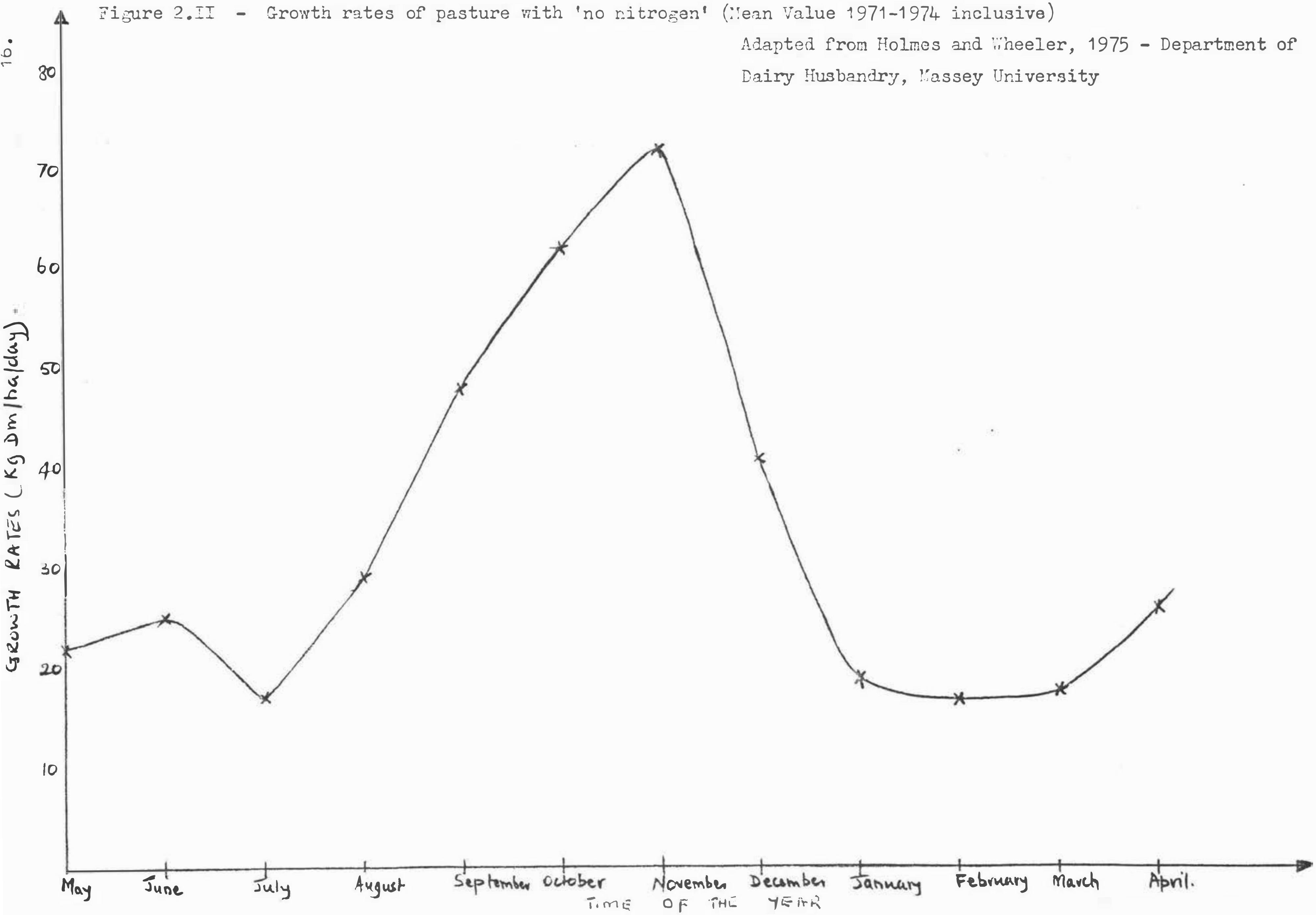
2:3:1 Climatic Factors

It is well established that temperature, light energy and rainfall have a marked influence on growth and yield of pastures (Lazenby, 1967; MacLusky & Holmes, 1963; Mitchell, 1955, 1956; Brougham, 1957 and others). The average seasonal growth rates for pasture on the No. 3 Dairy Unit at Massey University for the last four years (1971-74 inclusive) is given in Figure 2:II. It is seen from the figure that where any of the climatic parameters is lower or higher than required pasture production suffers. For example, lower temperatures and higher rainfall in winter or high temperature and low rainfall during the summer lowers yield.

Growth is critically influenced by temperature, and it does not start until the soil temperature exceeds 42°F (5.6°C) as noted by Blackman (1936) cited by MacLusky & Holmes (1963). It is believed that the growth rate increases with increasing soil temperatures, but it may not continue to increase in direct proportion to temperature. For example, Mitchell (1955, 1956) found no response to increasing temperature within the range of 59° - 83°F (15° - 28°C). Brougham (1956b) noted that temperature may be low enough in late autumn, winter

Figure 2.II - Growth rates of pasture with 'no nitrogen' (Mean Value 1971-1974 inclusive)

Adapted from Holmes and Wheeler, 1975 - Department of Dairy Husbandry, Massey University



and early spring to limit pasture growth rates. Falling temperature and diminishing radiant energy in winter leads to a reduction in the rate of tillering and tissue formation. This lowers the yield of pastures.

Light energy is necessary for photosynthetic reactions of the plant. Brougham (1956a) noted that the potential yield may not be obtained because of the incomplete utilization of light energy at different times of the year.

Water is also important for photosynthetic reactions. The lower availability of moisture during the summer and early autumn may lead to low yields (Brougham, 1959a). Too much rainfall, however, in the winter leads to a decrease in yield maximum due to increased tissue deterioration (Brougham, 1959b).

In general when any of the above parameters is limiting the rate of growth of pastures is lowered, hence pasture production in terms of yield.

2:3:2 Soil Factors

The soil acts as a source of nutrients and as a medium for plant growth. The soil properties which are important as far as plant growth is concerned are:

(a) Level of nutrients in soil.
(b) Moisture holding capacity.
(c) The rate of infiltration.
(d) The base exchange capacity.

The most important of all is the soil nutrients and their availability. The physical conditions of the soil or sometimes texture determines the plant nutrients found in soil. Thus, the porosity, degree of flocculation and the organic matter and humus content are important in this respect (MacLusky & Holmes, 1963). It is stated that the structure and texture of the soil determines the availability of the nutrients to plants, the ability of the soil to warm rapidly, and the moisture holding capacity of the soil (Russell, 1952). Thus, a soil having a good structure and texture will have plants growing in it at their maxima provided other factors are equal.

Soils vary widely in natural fertility with respect to all nutrients required by the plants. Any deficient nutrient has to be provided through fertilizer application. Usually nitrogen, phosphorus and potassium are the major elements which plant husbandmen are concerned about. Of course, some trace elements may also be required for plant growth. Good soils with their fertility are important for pasture growth and hence yield.

2:3:3 Management Factors

The management factors include the following:

(a) Grazing management.
(b) Fertilizer application.
(c) Weed control.
(d) Introduction of new species of pastures.
(e) Control of pests and diseases.

2:3:3:1 Grazing Management: Grazing management has been observed to have a large influence on the amount of grass grown. The grazing management include the type of grazing method, the stocking rate and the type of stock used (McMeekan, 1956, 1961, 1964; Campbell, 1969; Holmes, 1962 and others).

The effects of animals on pastures are considered in view of the grazing system and the type of stocking rate used.

When animals are grazing, they defoliate, tread and deposit excreta on pasture. The three effects may have a great influence on the amount of pasture grown. There is a great deal of evidence both in New Zealand and overseas countries on these three effects of animals upon pastures. Work on defoliation has been done by Brougham (1956b, 1959a), Selection by Arnold (1960), Treading by Edmond (1958-1961), Campbell (1966), Excreta by Sears & Newbold (1942), Watkin (1954, 1957), Herriot & Wells (1963), Weeda (1967), McDiarmid & Watkin (1972) and others.

Defoliation: Frequent defoliation of pastures has been reported to have an influence on yield and nutritive value, higher yields being recorded with less frequent defoliation (Holmes, 1962). Since all plant species present in a sward, including weeds, are to a greater or lesser extent susceptible to defoliation associated with grazing, the photosynthetic activity of plants is reduced if all the leaves/parts capable of photosynthesising are removed. This in turn reduces the yield of pastures. Brougham (1966) stated that for a maximum yield from a plant community, such as ryegrass and clover, cocksfoot and subterranean clover, or even flat weeds and clover, it is essential that the amount of chlorophyll present in a sward is sufficient to trap or intercept most of the light energy that falls on any area of pasture. Light falling on bare ground is wasted and the farming process is thus inefficient. Heavy grazing is associated with heavy defoliation.

Heavy defoliation leads to less tillering of the species present in a sward. It also affects the development of the roots because the reserves are no longer 'building' up because of reduced photosynthetic activity. Brougham (1956b) has shown the effect of defoliating grass to 1" (2.54 cm), 3" (7.62 cm) and 5" (12.7 cm) respectively. He found that the grass cut to 1" had fewer leaves hence the efficiency was lower too. He also found that the 1" treatment took a longer time before full interception of light was achieved (24 days). From this cutting trial, it seems that hard grazing may lead to similar changes in growth of a pasture sward. The review by Holmes (1962) indicates that defoliation is beneficial provided it is not done frequently.

As noted earlier, pastures which are not defoliated may reach a stage where there is no more increase in DM. In effect the yield may decline because of aging, decomposition of the lower leaves and shading of the clovers (Smetham, 1973). This practice is not recommended because the nutritive value of pasture declines. Thus for better productivity of pasture a system of intermittent grazing or cutting with carefully determined periods of rest is required (Ministry of Agriculture, Fisheries and Food, Grassland Management Bulletin, No. 54, 1955, McKeekan, 1964). Lax grazing may be the answer here. Hard grazing, however, with good spelling is also recommended for pasture production especially during the autumn.

In general, the frequency and intensity of defoliation are important in influencing the yield and nutritive value of pasture.

Treading Effect: Edmond's work and others has shown that there is a reduction in potential pasture production (DM/ha/yr) due to treading. It is considered that the reduction in yield is mainly due to mechanical damage (Edmonds, 1970). Tillers and shoots are torn from the crown and stems and leaves are bruised. Similar damage may occur to the roots if the soil is very wet and pliable (winter). Soil structure (aggregation of soil particles) may be destroyed with a resulting loss of permeability to gases and water which lead to poor plant growth. Also, soil organisms which aid the soil permeability process through their burrowing habits may be destroyed.

Increasing stocking rates leads to a reduction in pasture production (Campbell, 1969) which is partly due to treading associated with higher stocking rates. Greater damage follows where soil moisture is at or above field capacity (Edmond, 1962). Thus in general treading effect reduces the amount of DM grown.

However, treading when controlled may be useful to pasture community. It opens up the sward for the light energy to penetrate the lower canopy. Also under heavy grazing the undesirable species which are susceptible to treading may disappear, for example weeds. The prostate plants may benefit since new tillers are encouraged provided the same treatment is not repeated from time to time before the plants 'get up'.

Excreta on Pasture: Evidence suggests that where the animals have full return of excreta in the field, provided climatic conditions are good, higher yields of pasture are obtained as compared with no return of excreta in the field. For example, Sears and Newbold (1942), Sears (1956) report 14,000 lb DM/acre = 15,700 kg DM/ha per annum on full return of excreta against 10,000 lb DM/acre/annum without dung or urine. Uneven distribution of excreta may not result in increase in yield of pastures to any appreciable extent.

Animals are the main means of transfer of nitrogen from the clovers in the sward to the associated grasses. Also animals speed up the cycling of all plant nutrients through the soil-plant-animal system (Smetham, 1973). Thus high stock numbers promote greater nutrient cycling than only moderate stocking rates hence higher yields of herbage, but this only occurs when static levels of nutrients in the soil are below those required for vigorous plant growth.

However, pastures which are contaminated with dung (faeces) and urine may not be acceptable to the animal. Areas affected by excreta may change in botanical composition and this may affect the yield of the individual species in the sward. For example, Watkin (1954, 1957) found that in places where urine was excreted, the grass was dominant (ryegrass) and where dung was deposited clover was dominant. Weeda (1967) working with cattle dung patches, also observed that there were more clovers (white) in areas where dung has been deposited. This change in botanical composition may affect individual yields although it may not necessarily affect the total yield of the sward.

Total Animal Effects: Although each animal effect on pasture has been studied in isolation, the three effects occur simultaneously under grazing situation. The grazing management system used determines the amount of grass grown. Thus, the aim of any grazing management is to ensure a large supply of nutritious grazing over the growing season and it should be utilized in such a way that physical waste of the herbage by the animal is minimized and the productive capacity of the sward is maintained (Holmes, 1962).

Basically there are two grazing management methods, namely continuous grazing or set-stocking in which the animals are allowed to graze under free range conditions (McMeekan, 1964); and intermittent grazing or rotational grazing which involves systems like strip grazing or break grazing and controlled rotational grazing. Strip grazing or break grazing and block grazing systems are intensive systems of rotational grazing (Wheeler, 1960). Controlled rotational grazing can either be extensive or intensive. Here paddocks are grazed when they are ready to be grazed and in no set 'order' (McMeekan, 1964). A third type of grazing management, known as zero grazing, has been used in countries like Denmark and Holland. The grass is usually cut and taken to the animals and fed when green. This is said to achieve complete utilization of the herbage by that animal.

The amount of grass grown under any system of management will depend on the stocking rate, the frequency of defoliation and the severity of defoliation (Brougham, 1970a). Hard grazing with long enough spelling periods may be preferable, but lax grazing is usually the method recommended for dairy cows (Holmes, 1962).
Robison and Simpson (1975) noted that the benefits of any grazing management may not be seen when excessive stocking rates are employed. Thus the three effects, i.e. defoliation, treading and excreta on pasture, have to be considered when any grazing system is to be used since they have an influence on pasture production and utilization.

2:3:3:2 Other Management Factors: These include fertilizer use, weed control, use of new species of pastures and the control of pests and diseases. When other factors in the environment are optimum, the above management practices can alter the production of pasture.

Application of fertilizer is a common practice designed to improve pasture production. Holmes and Wheeler (1975) obtained an increase of 23% and 34% in total pasture production in the years 1971 - 1973 and 1973 - 1974 by applying 350 - 440 kg N per ha/annum.

The rates of application correspond to 7.4 to 10.5 kg DM grown per kg nitrogen applied. This is a substantial increase in pasture production. Increases may also be obtained from the addition of other elements when limiting.

Controlling weeds undoubtedly increases the productivity of pastures. Beggs (1971) concluded from his trial that controlling Tauhinu weed resulted in a huge increase in pasture production. Other management practices such as use of fertilizer and good grazing management were also included in the trial. Certain grass species may even be regarded as 'weeds' simply because they lack palatability, cause mechanical injury, or are poor in herbage production (Harris, 1970). This will result in lower productivity from the pasture association. Harris (1970) commented, however, that the word 'grass weed' has to be used with 'caution' since a weed in one situation may not be a weed in another situation. For example, Grant and Rumball (1971) in their review of Ecological and Control of barley grass have shown that barley grass is useful in some seasons of the year both here in New Zealand and Australia. Thus, the recommended word is 'volunteer plants' in a sown sward. The volunteer plants therefore, reduce pasture production because they compete for nutrients in the environment, and if they are successful in establishing themselves in the sward, the total pasture production is lowered. Some may be unpalatable, thus lowering the feeding value of the sward. Thus controlling volunteer plants which are not desired in a sward may increase the total pasture production.

The use of new cultivars may improve pasture production too. New varieties of grasses are always being tested for their productivity, e.g. Ruanui grass, Ariki, Prairie, etc. The new varieties may prove superior to the old ones in terms of production. Some varieties may also be suited for certain seasons of the year adding to the availability of pasture grown throughout the year or season, e.g. Prairie grass in winter.

Controlling pests and diseases of plants may increase the amount of dry matter (DM) grown and its utilization by the animals. For example grass grub in some parts of the country may be a problem and leave certain areas as bare ground. Control of such pests may increase pasture productivity.

Filling up spaces by surface reseeding, e.g. overdrilling, direct drilling and oversowing, may prove useful in increasing pasture production. This ensures that there is no bare ground without a plant (Baker, 1971).

Therefore management of pastures for higher productivity can be done provided environmental conditions are good. This in turn will increase animal production since more animals can be carried per hectare basis and per hectare production increases. In the following section the methods of assessing feed on hand are reviewed. Also the use of feed budgeting as a tool for managing farms is reviewed.

2:4 Assessment of Feed Quantity and Feed Budgeting

It is important to assess pasture available on the farm so that the feed can be rationed to stock according to requirements, (Parker, 1973). In addition, if overall deficiencies on the amount available are recognised, something can then be done about the situation. Supplementary feeds could be bought in or extra feed grown by changing management procedures. For example, the use of fertilizer nitrogen, oversowing or use of irrigation.

2:4:1 Methods of Assessing Feed Quantity

There are currently three methods of assessing pasture cover on farms/research centres namely (i) visual assessment, (ii) the cutting, washing, drying and weighing method, using random plots on the farm, (iii) the use of instruments developed by research workers, e.g. capacitance probe, weighted disc and grass meter (plate).

(i) Pasture assessment by eye as used by Hutton and Parker (1973) is difficult to do with a reasonable degree of accuracy

(Ministry of Agriculture and Fisheries, 1975). However, with properly trained advisers, pasture assessment by eye can result in fairly accurate estimations of pasture yield. Cross-checking with cutting technique may be necessary once monthly.

(ii) The cutting technique involves the cutting, washing, drying and weighing processes. This is said to be a more accurate method if the cutting is consistent and is as close to ground level as possible (MAF, 1975; Parker, 1973). However, it is not always possible to be consistent in the height of cutting and this leads to variation in the amount of dry matter present on the farm. Also, since quite a few steps are involved in determining the amount of DM, this may lead to errors of estimates. Thirdly, the method is time consuming and needs drying facilities, e.g. an oven, thus making the method unacceptable in farming situations when used on its own.

(iii) Instruments like the capacitance probe, weighted disc and the grass meter to assess pasture dry matter yield have been used (Campbell et al, 1962; Powell, 1974; Bryant et al, 1971; John et al, 1965; Smith, 1974; Holmes, 1974 and others). The use of the capacitance probe has given inconsistent results in the past, so that the use of the weighted disc and the grass meter will depend on the consistency of the results which will be obtained. However, the use of these instruments so far, have shown some variation in pasture dry matter measurements. For example, Holmes (1974) obtained a variation of about 224 kg DM/ha using the grass meter over 14 months on Dairy Unit No. 3, Massey University. Powell obtained a variation of about 434 kg DM/ha for winter irrigated pasture in using the weighted disc. It seems therefore that the two instruments also give inconsistent results. None-the-less, Holmes (1974) and Powell (1974) concluded that the use of the two instruments in measuring the total dry matter in winter and early spring on dairy pastures are reasonably accurate for the purposes for which they are intended.

The grass meter and the weighted disc use the same principle, and they are calibrated against pasture dry matter by the cutting, washing, drying and weighing technique.

It is, however, to be noted that the weighted disc and the grass meter techniques of assessing pasture yield are dependent on the relationship between pasture height, density and dry matter yield, which varies with the season of the year (Powell, 1974). For example, Parker (1973) noted that assessment of pasture DM is influenced by height, density and species composition in a sward, for example, legumes have a lower DM percentage than grasses. He also noted that DM changes with the season being lowest in the spring and highest in the summer. So, in effect, where pastures differ considerably in species composition and density, separate calibrations may need to be taken, otherwise large errors may result when using the above instruments.

The use of any of the above techniques to assess the pasture yield (DM) during the winter or any other season of the year is important for feed budgeting. However, each one has its own limitations as noted earlier, and in all cases, the cutting, washing, drying and weighing procedures are involved at least once in a while for the purpose of calibration.

2:4:2 Feed Budgeting

Feed budgeting has been defined as an estimation of feed on hand plus pasture and crop growth put alongside an estimation of animal requirements to see how the two match over a period of time (MAF, 1975; Frengley, 1973).

In New Zealand, the critical period of feeding cattle is over the winter and early spring. In winter and early spring, the grass growth rates are low due to low temperatures and light energy deficit, therefore the grass supply is low. The animal requirements are quite high as compared to pasture growth. Thus budgeting the feeds becomes important at this time of the year.

The objective of feed budgeting is to make better use of feeds without serious consequences on the animals hence future production. In order to achieve this objective, manipulation of feed demand and feed supply is essential. In doing this, it is suggested that farmers gain a better understanding of animal requirements, better pasture and animal husbandry, and in addition assessment of the feed supply and demand which give earlier warnings of surpluses or deficits (Webb, 1975; Riddler et al, unpubl.). In many situations, optimum allocation of the feed between pre- and post calving needs have to be established.

2:4:2:1 Methods of Feed Budgeting: MAF (1975) described two methods of budgeting feeds, namely: (i) Feed requirements for various mobs of stock are estimated for daily, weekly or ten day periods etc, and feed growth is estimated for the same period. The feed on hand is monitored for each period (short periods of time for budgeting are involved here).

(ii) Feed requirements for one or two mobs of stock are estimated for the whole period under consideration (usually full season etc.) and compared with the feed on hand plus the expected growth of feed for the whole period.

It is generally agreed that the first method is accurate but it is complicated and takes time for the calculations to be done whilst the other method is not so accurate but takes a shorter time to compute the necessary calculations. MAF (1975) publication recommends the second method as the one often required by the farmers.

2:4:2:2 Reconciliation of Feed Supplies and Stock Requirements: The DM of feed has been used as the basis for reconciling feed supplies and stock requirements (Frengley, 1973). In budgeting feeds the same system may be applied, although a system based on cow-grazing days has been used by farmers in the past, and it is still in use in some areas of the country.

Jagusch (1973) has worked out the requirements hence the feed budget using metabolizable energy (ME) system. This method may be more accurate as it takes into account variations in feed quality (Frengley, 1973). However, in practice there are difficulties involved in obtaining pasture and animal data. Secondly farmers may not be so keen to accept complicated systems. It is however noted that the ME system is suitable in research work hence its adoption in research centres.

2:4:2:3 Adjustment to Feed Supplies: For budgeting purposes, future growth is predicted on the basis of previous data on pasture growth rates. However, climatic differences between years may modify the trends in pasture growth so that what has been estimated may not be the same as the actual and thus any budget needs continual updating.

Generally farmers have minimal control over the climatic factors that affect pasture production. They can, however, control other variables that contribute to the total feed supply to a certain extent by:

(i) Transferring feeds. Surplus pasture in times of plenty can be conserved conventionally to overcome the deficits or can be held *in situ* for short periods and used later, e.g. Autumn Saved Pasture (NZ).

(ii) Purchasing feeds. Feeds may be bought in, in form of hay, mangels, concentrates and sometimes silage. Buying of feeds is sometimes more expensive than using home grown feeds.

(iii) Introducing grass species with more vigorous growth and can persist for the winter season, e.g. Prairie grass.

(iv) Changing the resources that affect plantgrowth, for example fertilizer application, irrigation where moisture is limiting and where it is feasible, and drainage of water in wet soils (Frengley, 1973).

(v) Grazing management. As noted earlier, this is an important aspect in grassland productivity. Heavily grazed and trodden pasture may not recover fast therefore growth is slow. In moderately grazed swards, the treading effect may not be so apparent, and this may ensure adequate feed supplies (Harris & Brown, 1970). However, quick hard grazing with long spellings as suggested by Parker and Willis (1973) may be as good. In the following section the wintering systems available (NZ) are reviewed.

2:5 The Wintering Systems

Various systems of wintering stock have been described in various books and journals. The systems range from zero grazing (grass cut and carted to animals which are housed or held in a paddock) to more intensive systems of rotation. These wintering systems have different effects on pasture species and hence on production per hectare (Kirton, 1967; McKenzie, 1961).

It was noted earlier that the aim of any wintering system is to avoid as much as possible wastage of feed through treading and fouling. To achieve this, the feed has to be rationed to stock according to their restricted requirements (Wallace, 1958; Hutton, 1962). Wallace (1958) noted that cows are capable of eating large quantities of pasture (Autumn Saved Pasture ASP) in a very short time. This 'brings' up the possibility of minimizing the time spent on an area (break) so as to reduce treading and fouling effects. In such a system cows can be held in a race or on concrete (or sawdust) when not actually eating.

Essentially, there are two methods of grazing, namely continuous grazing or set-stocking, and rotational grazing (Wheeler, 1960, 1962; Smetham, 1973). From the two methods of grazing various systems of wintering have been established here in New Zealand. These systems are reviewed.

2:5:1 Block or Strip/Break Grazing or Paddock Wintering Systems

These are intensive rotational systems in which electric fences are used to ration the feed to stock according to the restricted requirements. They are aimed at minimizing treading damage and on the other hand increasing the amount of feed grown (Smetham, 1973). On some occasions one paddock has to be 'sacrificed' for holding the stock during the wet conditions and when the soil is at or above field capacity (Matthew, 1971; Smetham, 1973). The sacrificed paddock or break has to be ploughed and reseeded during the spring, or some other suitable time. The pugged paddock is alternatively used for cropping (McKenzie, 1961).

The advantages and disadvantages of hard grazing with long spelling have already been covered earlier in this chapter. It is however to be noted that the 'block', strip or paddock grazing systems may be good systems where the soils drain freely with a good mixture of pastures (Parker & Willis, 1973); for example in Taranaki, Parker and Willis (1973) noted that pugging (or poaching) as defined by breaking off of soil surface through treading, occurs to only a limited extent and only where high stocking rates are associated with heavy rainfall. The two workers argue that treading effects of about 350 to 500 cows per hectare per day in normal weather conditions appear to be beneficial. Severe poaching necessitating oversowing is estimated to occur on the average on no more than 1% of the block wintered area.

The systems usually include the use of variable quantities of autumn grown pasture which is saved for use during the winter. This is then rationed to cows along with hay or silage when required (McKenzie, 1961). If the climate is favourable for pasture growth, some of the saved pasture will deteriorate in quality, that is overmature and partly rotten and in effect the clovers would be shaded making the sward of poor quality (Kirton, 1967).

2:5:2 On/off system

The on/off system with a platform or sawdust, concrete, shingle or straw standing areas during periods of wet weather and sometimes feeding them hay or silage in here. This system is recommended on heavy wet soils and also in wet weather. Hutton (1971) pointed out that the on/off grazing system is unavoidable in wet weather, and this is true if the life of pastures is to be spared. Wallace (1958) stated that the on/off system has the advantage that overgrazing and excessive trampling are avoided. Also the level of feeding can be controlled and the pasture is left with reasonable cover after grazing so that the subsequent rate of recovery is rapid.

The on/off system has been compared with other systems of grazing on productivity of animals. McQueen (1970) however, suggests that the use of platforms or yards is not only to gain substantial productivity from cows, but also to reduce pasture damage through poaching, pugging, etc., thereby obtaining more control over the feed supplies at other times of the year. For example, one Northland farmer had to use a barn to winter his cows from 1972 to date, and he finds it quite convincing since he has increased his feed supplies (no more heavy pugging) and also his production has gone up from 30,000 lb - 42,000 lb BF (13,640 - 19,091 kg BF). He is also carrying more stock than in 1972 (Heddley Dunn 1976, N.Z. Dairy Exporter, March, pg 15).

Thus, the use of on/off systems during the wet weather conditions may bring a 'near enough' balance between the soil-plant-animal eco-system. As Brougham (1970b) concluded, there is a need to put emphasis on ecological studies where the whole rather than part of the complex (soil-plant-animal complex) is studied. There is a need to look into any system of wintering whether it does achieve a 'near enough' eco-system. This may mean more work of experimentation in the future.

The main disadvantages of the on/off system include the extra work in moving the stock, the capital costs of platforms and/or buildings, and often the loss/transfer of fertility (faeces and urine) from the grass eco-system.

2:5:3 Set Stocking

This is another system which is appropriate at moderate stocking rates or low stocking rates. Pastures which are adequately stocked and are not too wet as to damage the pasture can be kept short and leafy and there will be little wastage of feed. However, if the climate becomes unfavourable for pasture growth, the feed available may not be enough to meet cow requirements. On the other hand, when the climate is 'very good' for pasture growth the feed produced may be higher than cow requirements and this may mean wastage of feed or at least a deterioration in quality. This method may give a variation in the levels of feeding in that cows get more feed to start with and get less as time progresses. In practice the proportion of the farm used for the system can be varied to overcome the problems raised (McKenzie, 1961).

In general, any system of wintering used in any locality will be acceptable depending on the conditions of the area itself, provided that the system does not affect the future production of feeds and production of the animals being wintered. The following chapter is a description of a trial carried out at Massey University No. 3 Dairy Unit of comparing two wintering systems of managing dry dairy cows. The objectives in mind were to ensure that cows calve in satisfactory condition, and that enough feed is available in early lactation to meet animal requirements.

CHAPTER 3

EXPERIMENTAL METHODS

3:1 Introduction

The trial took place in the winter of 1975 on the No. 3 Dairy Unit - Massey University. The area of the whole farm was 105 acres (42.5 ha), and 64 acres (25.9 ha) were utilized for the trial.

The total number of stock on the farm at the end of May was 155: 93 mature cows, 35 two-year-old, and 27 yearlings. At the end of August there were 69 mature cows, 35 two-year-old, 26 one-year-old and 35 calves.

The soils are described as Tokomaru Silt-loam with alluvial soil profile showing 6" - 8" (15.24 - 30.32 cm) dark brownish grey heavy silt on a mottled clay loam (Matthew, 1971; Edmond, 1965). In the last few years, the soils have been drained intensively with tile and mole drains (Holmes and Wheeler, 1975).

The pasture was essentially a mixed sward of ryegrass and white clover. The individual species may be described as Manawa, Cocksfoot, Ariki, Prairie, Ruanui and white clover (Wilson, Pers. Comm.).

3:2 Experimental Procedures

The aim of the experiment was to compare two winter grazing management systems. The broad objective of the study was to develop a management system which involved less supplementation, and at the same time provided adequate feed supplies over the winter and early spring to meet herd requirements.

The parameters studied within the two management systems were: grass growth rates and recovery, pasture damage by pugging, the amount of grass consumed, live weight changes, milk production for the first three months of lactation and the average cover on the farm.

3:2:1 The Trial

Eighty-four cows, that is 68 mature cows and 16 heifers all pregnant and expected to calve in July/August were divided into two groups each of 42 cows at the end of April.

Thirty-four paddocks of No. 3 Dairy Unit were allocated to the trial. The paddocks varied in area between 0.56 ha - 1.16 ha, thus giving a total area of 25.9 ha for the trial. The area was divided into two equal farmlets each with an area of 12.95 ha during the trial period. Two grazing managements were then applied to the two farmlets (see Appendix I for the layout of the farm, hence the trial).

Farmlet A (Treatment A) was the lax-grazing management (on/off), and Farmlet B (Treatment B) the hard grazing management (on). Each treatment had equal numbers of stock (42 cows), and therefore the two treatments had the same stocking rate. In order to avoid confusion the group of animals in Treatment A were called the on/off group, and those in Treatment B were called the on group. Thus:

Treatment A (on/off group)		Treatment B (on group)	
No. of Stock:	42 cows 35 mature 7 heifers	No. of Stock:	42 cows 33 mature 9 heifers
Total area:	12.95 ha (32 acres)	Total area:	12.95 ha (32 acres)
Stocking rate:	3.25 cows/ha (1.313 cows/acre)	Stocking rate:	3.25 cows/ha (1.313 cows/acre)
No. of paddocks:	17 of varying sizes	No. of paddocks:	17 of varying sizes

<u>Treatment A (on/off or lax-grazing)</u>: The 42 animals of this group were allowed to graze on pasture for a limited period each day, and were then removed to spend the remainder of the day on a concrete area on a race.

An area of pasture which would be grazed by the cows to satisfy their dry matter intake from grass was allocated daily to this group at 9.00 a.m. The time allowed to graze the break was between $2\frac{1}{2}$ - $3\frac{1}{2}$ hours and the animals were then removed to the hard area for the remainder of the day. Hay was fed to the group on the hard area.

The period of grazing was chosen so that a 'suitable' stubble (cover) was left on paddocks after grazing. The aim was to leave 900 - 1000 kg DM/ha as post grazing stubble.

Treatment B (on or hard grazing): The animals in this group remained on pasture at all times. An area of pasture was allocated to the group at 9.00 a.m. and the group remained on the 'break' until 9.00 a.m. the next day. Hay was fed on the breaks when the animals were grazing the new area allocated.

For this treatment the aim was to leave 400 - 500 kg DM/ha as post grazing stubble (Plate I - On-group on a break of pasture).

3:2:2 Start of the Trial

Before the start of the trial the average cover on each of the farmlets was assessed by eye and grass meter. The grass meter was calibrated against pasture dry matter determined by cutting a few days prior to the start of the experiment. Fifteen readings were taken from each paddock using the grass meter and then averaged to give the amount of DM in the paddock. The average dry matter for 17 paddocks gave the average cover on each farmlet. A feed budget was then prepared for each farmlet (see Appendix II) using grass growth rates from previous years (1971-74 , Holmes and Wheeler, 1975) and cow requirements data (Davey's 1974 Handout).

The trial was started at the end of April and finished in mid-July 1975. The trial was discontinued because a number of cows had calved and it was becoming difficult to manage different mobs (groups) on the farm. So it was decided that all the dry cows be put together and the lactating ones put together too. However, the growth rates of grass were continued to be measured until the middle of August.

3:2:3 Measurements

The measurements taken during the trial period were:

(a) Estimation of dry matter in each paddock before grazing and cover on each farmlet. This was necessary so that the grass could be rationed to stock, and to know the 'position' of feeds on the two farmlets.

(b) Estimation of dry matter consumed by the cows in each paddock.

(c) Live weight changes of cows.

(d) Grass growth rates.

(e) Milk production recorded after calving.

3:2:3:1 Estimation of Dry Matter in each paddock or per hectare before grazing: The three methods reviewed already were used. However, the main ones were the cutting method and the grass meter for the assessment of grass cover on each of the paddocks.

(a) The Cutting Technique: About fifteen samples from a paddock to be grazed were cut. The grass was cut to ground level within rectangular frames of 60.96 cm x 30.48 cm (2' x 1') placed randomly within the paddocks to be grazed (see Plate II). The cut samples were washed to remove soil, and dried separately for 24 hours in trays in an oven at a temperature of about 85°C+. The samples were checked the next day and when they were thoroughly dry, weighed to estimate the amount of DM in the paddock or per hectare.

The residual DM (DM left after grazing) was also estimated using the same technique except that instead of using 60.96 cm x 30.48 cm rectangular frames, 60.96 cm x 60.96 cm (2' x 2') rectangular frames were used. A portable shearing machine with a hand piece was used to cut the grass for both the ungrazed and grazed paddocks, and the grass was collected and put into plastic bags (Plates III and IV).

(b) The Visual Technique: Before the cutting technique was carried on, the DM on each paddock was estimated by eye first. It was not the main method of DM estimation.

(c) Use of the Massey Grass Meter: Prior to its use to estimate the DM in each paddock or each farmlet, it was necessary to calibrate it as described by Dr Holmes in Dairy Farming Annual 1974.

The calibration of the grass meter was done monthly. The grass samples were cut from various paddocks (long, short and medium) at random, so that various readings were obtained which corresponded to various dry matter figures. About 20 - 30 samples were taken from whole farm for calibration work. After cutting, each sample was washed, dried and weighed separately. The meter reading corresponding to each dried grass sample was plotted on a graph. Linear regression analyses were initially carried out to obtain the relationship between lines as described by Snedecor and Cochran (1973, pg 135).

After calibrating the meter, fifteen meter readings were taken from each paddock by simply placing the meter on grass gently and the plate rises and the reading taken on the rod scale. Plates V and VI show the grass meter and its use respectively. The mean reading of 15 samples from each paddock was worked out and this mean was read off against the calibration curve, thus giving an estimate of DM present on the paddock.

3:2:3:2 Estimation of Grass consumed in each Paddock: The dry matter consumed in each paddock was estimated as follows: The paddock to be grazed was cut before the animals were allowed in to estimate the amount of DM available. After grazing, the clipping operation was repeated to estimate the residual DM. The difference between the two (DM before grazing and after grazing) gave the amount of DM eaten by the cows. This amount of DM in each paddock and in each farmlet divided by the number of days which the dry matter lasted, gave the amount consumed/cow/day.

It was not easy to estimate the amount of dry matter left in a paddock, particularly with the on-group. A paddock may have 10 'breaks' and since cows have to stay in a break for 24 hours, the grass may be 'overeaten' and trodden so that there was no grass that could easily be clipped. The conditions became worse when it was wet, which led to heavy pugging (Plates VII and VIII). However, where the possibility of cutting grass was nil because of heavy pugging, visual assessment was used. This has been done in four breaks of various paddocks in farmlet B.

There was no problem in cutting the grazed breaks of the on/off group, because most of the paddocks had 3 - 5 breaks and these were clipped every second or third day when the cows left the last break for a fresh one in another paddock. For the on-group, three breaks were sampled every third day the cows were moved to a new break. For example, if a paddock had nine breaks, it took three days to sample. About three clippings were taken from each break. The average dry weights of the samples was worked out and multiplied by a factor of 26.833 to give kg DM/ha left on a paddock.

For the ungrazed paddocks a factor of 53.67 was used to give kg DM/ha.

3:2:3:3 Live Weight Measurement: Two days prior to the start of the experiment, the cows were weighed twice to obtain an average live weight of each cow in each group. After the commencement of the experiment, the cows were weighed every week on Wednesday starting at 8.30 a.m.

The weighing was done for each cow in each group before a new break of feed was allocated to the group. The weights were recorded from each cow and averaged to obtain the mean live weight of each group for each week.

Average live weights of both mature cows and heifers were also recorded for comparisons as to whether the cows were gaining more than the heifers.

3:2:3:4 Estimation of Pasture Growth Rate and Pasture Damage by Pugging:

(a) Growth Rates: The growth rates were estimated as follows: A paddock was cut after being grazed to estimate residual dry matter. After approximately 21 days, the grass was cut again (15 samples from each paddock) to estimate the amount of dry matter grown within that specified period. The difference between the two (the grown DM and the left DM) gave the amount grown. This amount grown divided by the number of days it took the grass to grow, gave the rate of growth of pasture per day (kg DM/ha/day).

(b) Pasture Damage by Pugging: This was assessed by eye and some snaps were taken of the areas which were heavily trodden and pugged. Plates VIII and IX show this effect of pugging. The areas pugged were recorded.

3:2:4 Statistical Analysis

There was no particular statistical design followed in this trial. However, statistical analyses were carried out where they were applicable. For example, analyses of linear regression as described by Snedecor and Cochran (1973) pg 135, the t-test in comparing the growth rates between the two systems and also between the techniques of cutting and visual assessment of pasture DM. Other simple statistical analyses, e.g. standard error of the mean, were also carried.

Plate I Grass rationing to on-group using movable electric fences (may 1975)

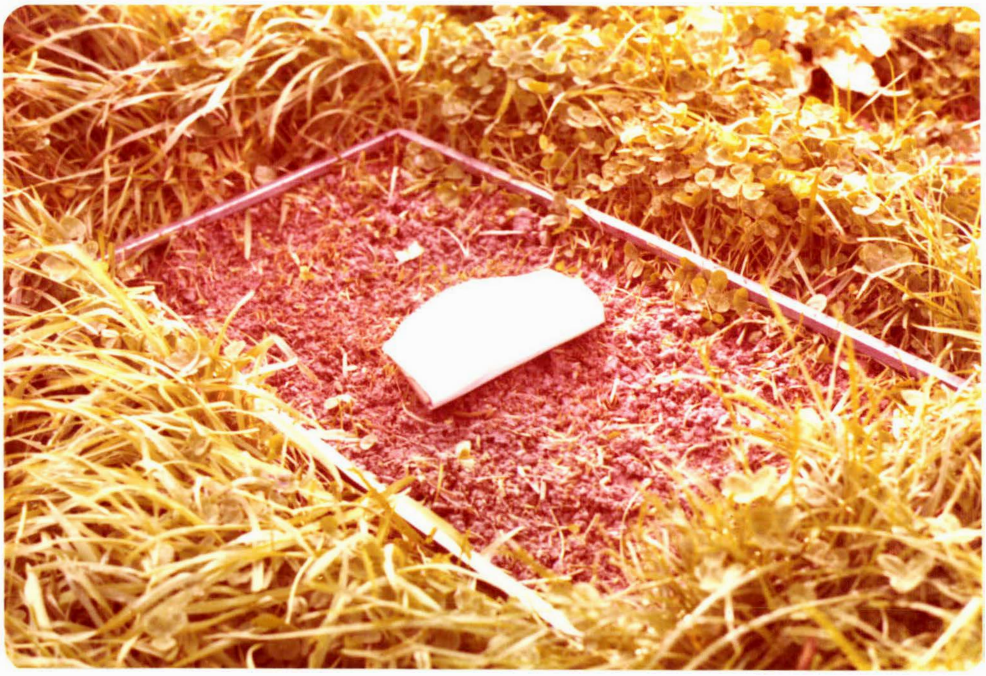


Plate II: Cutting a paddock to ground level before grazing (on/off group June 75)

Plate III: Clipping a grazed paddock to ground level (on-group)

Plate IV: Putting the clipped grass in plastic bags.

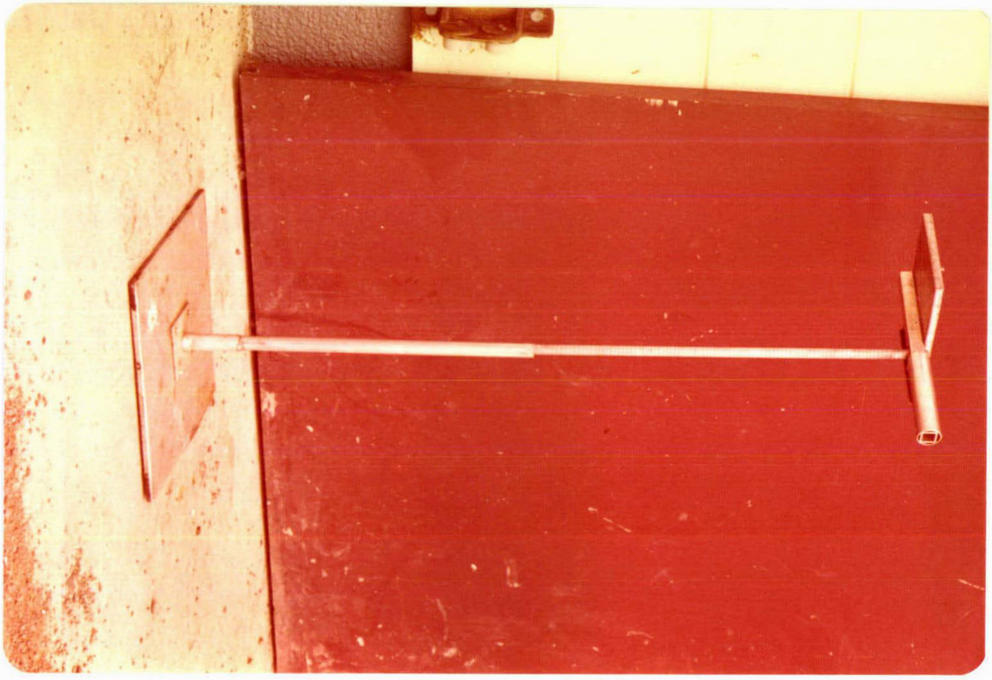


Plate V: The grass-meter on concrete floor

Plate VI: Measuring grass cover using grass-meter

A B

Plate VII: paddock 24

A: This break was grazed when wet. Difficult to cut the grass when overeaten & trodden.

B This break was grazed when not wet. The grass is coming up fast.

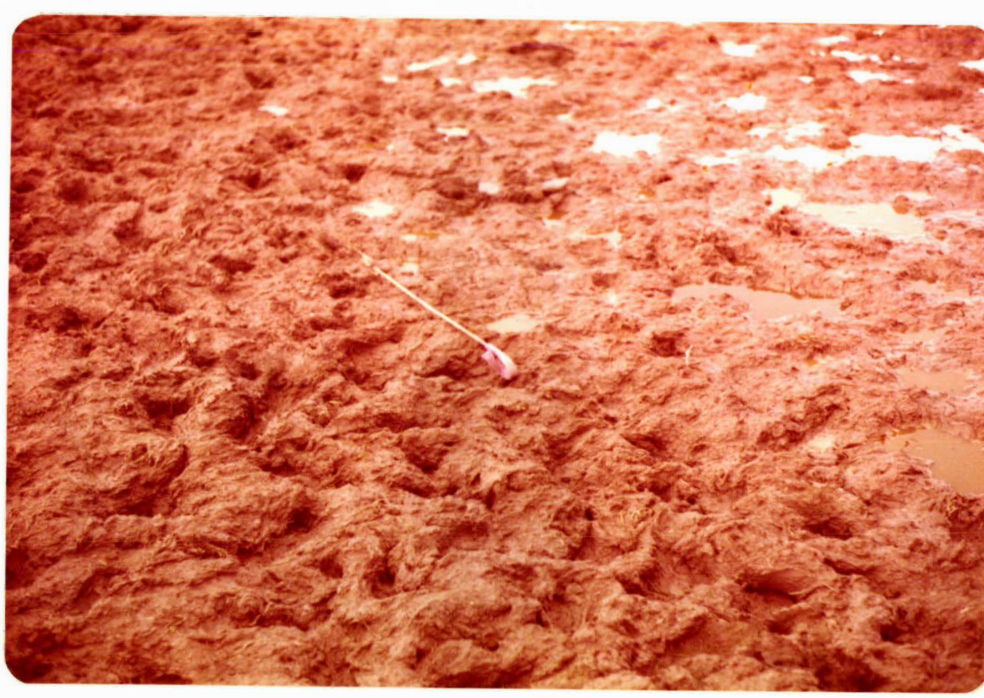


Plate VIII: paddock 24. Heavily pugged break— 1 day grazing and heavy rains at night.

CHAPTER 4

RESULTS OF THE EXPERIMENT

4:1 The Grass Budgets

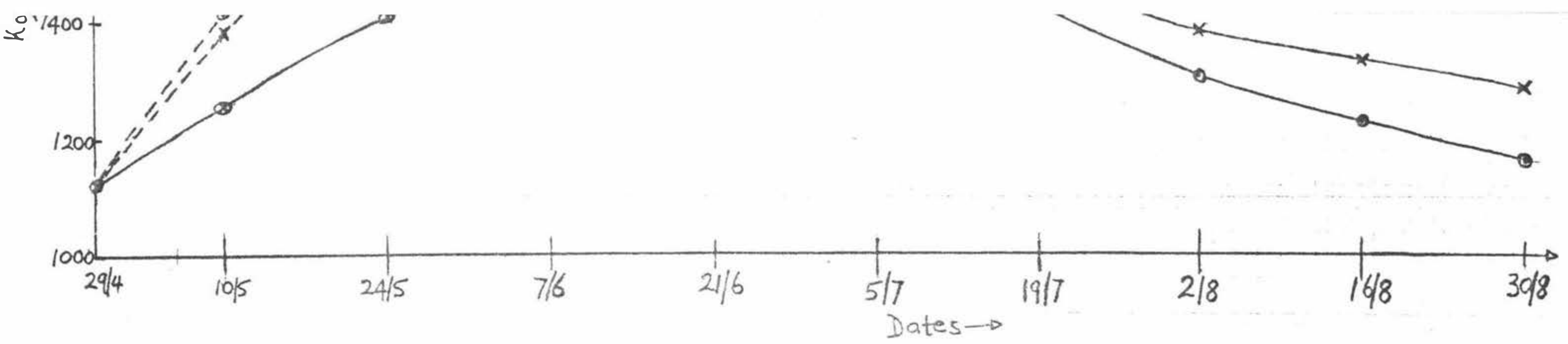
Grass budgets were drawn up for each farmlet prior to the commencement of the experiment in order to formulate feeding plans and to provide an expected average 'grass cover curve' to act as a guide for possible changes in management during the course of the experiment.

For the sake of budget, it was assumed that the average cover on both farmlets as at 30.4.75 was 1120 kg DM/ha. This was obtained by visual assessment for which its accuracy can be gained by looking at Appendix VII. It was also assumed that the cows would calve from mid-July onwards. The details of the assumptions made as to the likely grass growth rates, the requirements of the animals, together with the methods of calculation used are given in Appendix II. The average 'grass cover' on each of the farmlets with and without the addition of hay are given in Figure 4.I.

On the basis of the budgets it was decided initially that a greater quantity of supplementary hay should be fed to the on-group in order to achieve similar total yields on the two farmlets during late August early September. Because grass growth rates were not as high as expected (see Table 9a and b or Figure 4.IX) and the measured actual 'grass cover' fell below the expected 'grass cover', especially on the on/off treatment, more hay had to be fed to the on/off group (see Table 9a and b) than was anticipated in the budget.

4:2 Calibration of the Meter

The meter was calibrated on the following occasions: 23rd of April, 16th of May, 14th of June and 5th of July, 1975. In the case of the July calibration, separate relationships were obtained for the


Ko
1400
1200
1000
29/4
10/5
24/5
7/6
21/6
5/7
19/7
2/8
16/8
30/8
Dates→

two farmlets. The relationship between DM obtained by cutting and meter readings is shown graphically in Figure 4.II. The data for April and May, and the data for July On/off and On respectively, were combined for convenience of drawing the curves. Linear regressions were obtained for each month and these are given in Table 4.1.

Table 4.1 - Linear Regression Equations obtained for each month during the trial period

Month	Estimated Regressions	
April	$\hat{y} = 9531.1 - 102.3x$	Combined
May	$\hat{y} = 9023.2 - 94.5x$	$\hat{y} = 9946 - 106.36x$
June	$\hat{y} = 9911 - 108.4x$	
July		
On/off group	$\hat{y} = 11849.8 - 133.45x$	
On group	$\hat{y} = 11747.6 - 132x$	

$\hat{y}$ = Pasture Dry Matter

x = Meter reading

Close examination of the graphs indicated that the relationship was not always a straight line (for example June) so curvilinear lines were fitted by eye as shown in Figure 4.II. The importance of fitting a curvilinear line instead of a straight line relationship is illustrated in Table 4.2 in a comparison of grass covers for the two farmlets for June as determined by both methods.

Figure 4.II: Calibration curves of grass meter readings and yield of pasture obtained by cutting

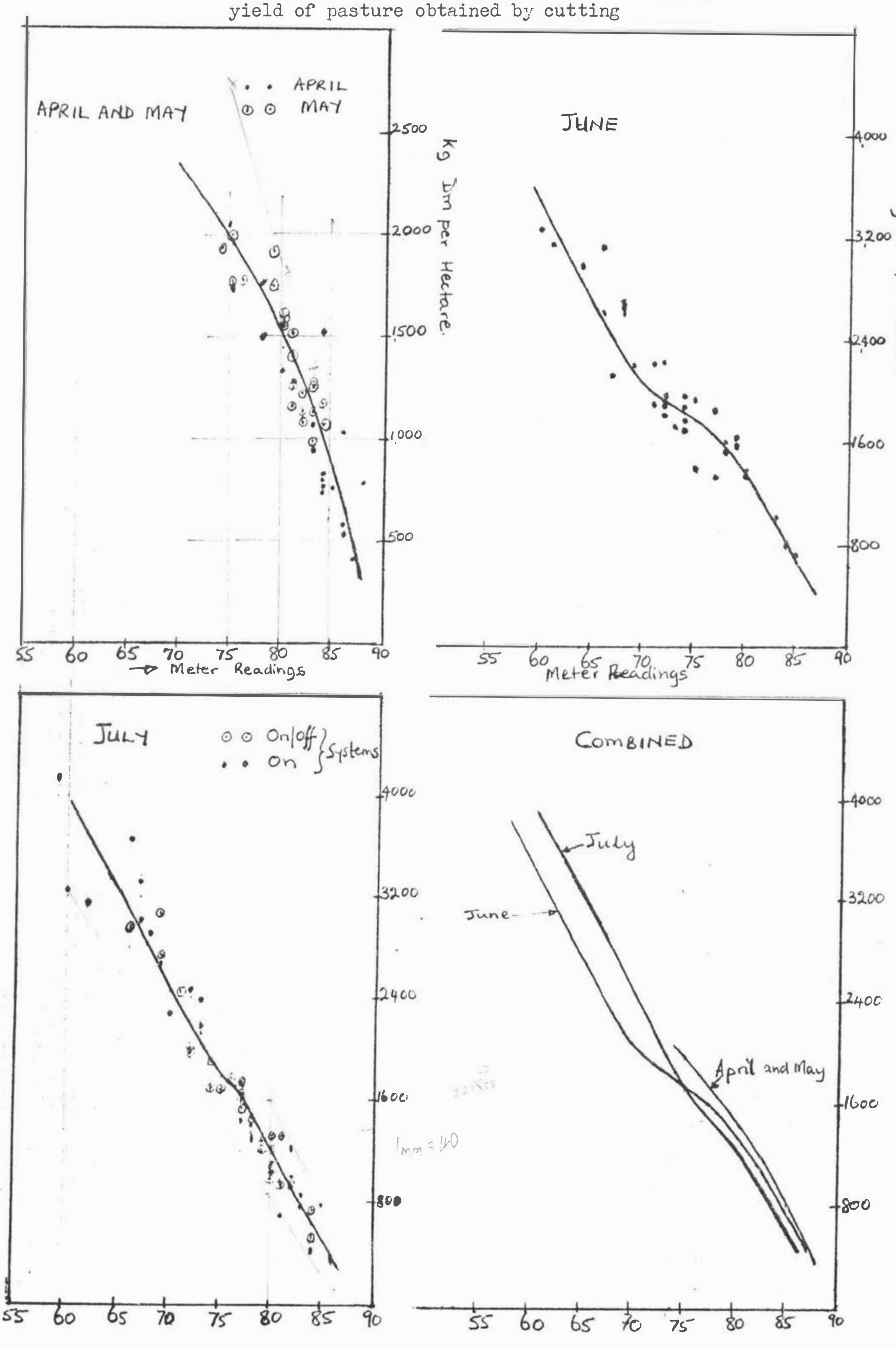


Table 4.2 - Comparison of grass covers on the farmlets in June determined using either the linear regression or curvilinear calibration curve (extracted from Appendix III).

	On/off System			On System		
	Mean Meter Readings for some examples of individual paddocks (15 samples)	Calculated Yield (kg DM/ha) Linear (L) Regression	Calculated Yield (kg DM/ha) Curvi-Linear Graph (C)	Mean Meter Readings for some examples of individual paddocks (15 samples)	Calculated Yield (kg DM/ha) Linear (L) Regression	Calculated Yield (kg DM/ha) Curvi-Linear Graph (C)
Short paddocks	81.0 78.5	1131 1406	1200 1490	85.3 82.9	664 925	650 975
Long paddocks	75.7 73.2	1709 1976	1775 1925	75.5 64.0	1727 2973	1775 2300
Mean for farmlet	76.6	1608	1660	74.0	1892	1820

Difference between calibrations within farmlets (C - L) = +52 kg/ha (C - L) = -72 kg/ha

Difference between farmlets
using (i) Linear 284 kg/ha
(ii) Curvilinear 160 kg/ha

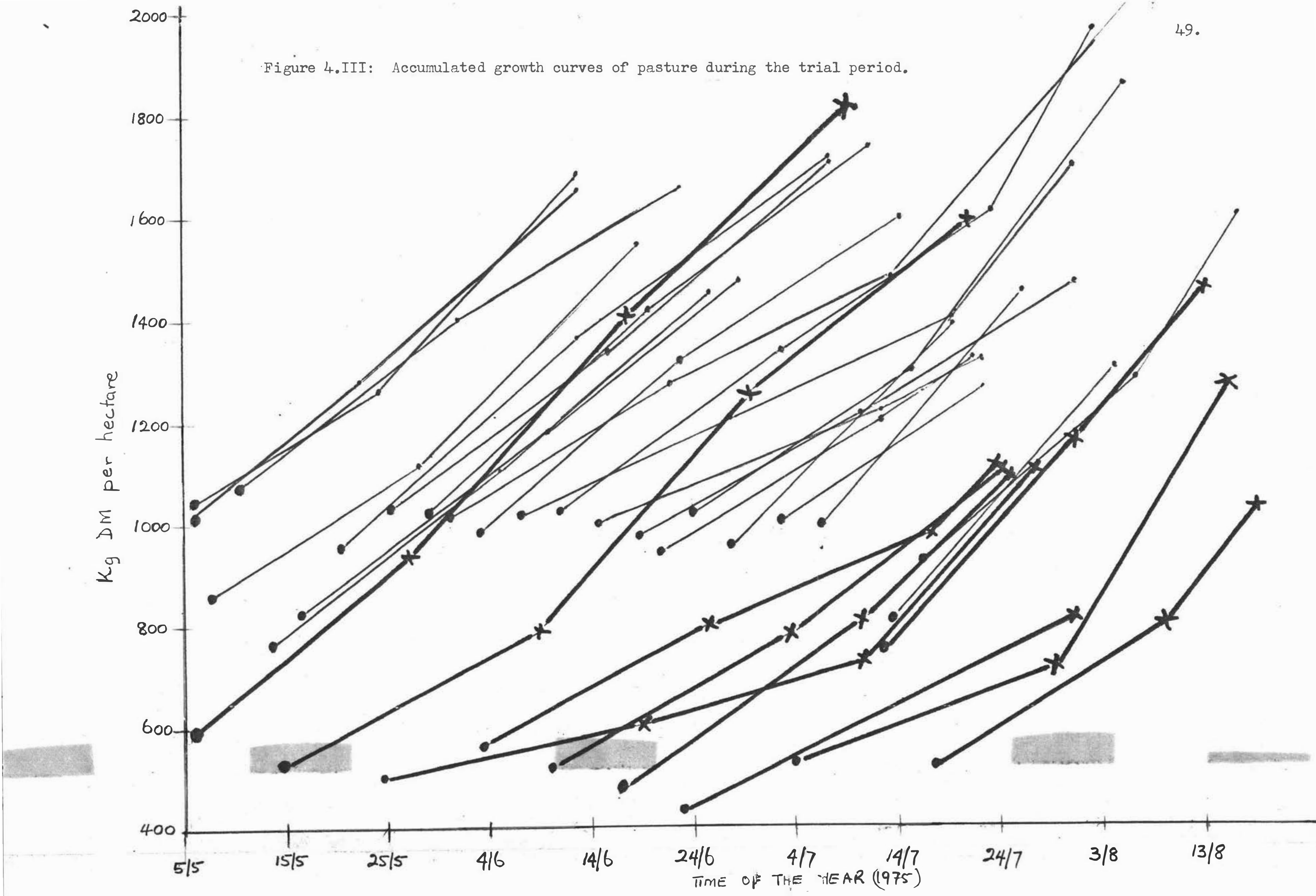
It is seen that the use of the linear calibration regressions exaggerates the differences between the 'covers' on the two farmlets.

4:3 Pasture Growth Rates

4:3:1 Regrowth Following Grazing

Rates of growth were calculated from the cutting data which were obtained at three weekly intervals following grazing. The data for individual paddocks are given in Appendix IV and illustrated graphically in Figure 4.III.

Figure 4.III: Accumulated growth curves of pasture during the trial period.



The mean growth rates for the paddocks actually grazed on each of the farmlets during the four months of the experiment are given in Table 4.3.

Table 4.3 - Growth rates of Grazed Pastures

Month	On/off System				On System			
	No. of Paddocks	Average Growth rate kg DM/ha/day	Range	Standard Error of the Mean ± SEM	No. of Paddocks	Average Growth rate kg DM/ha/day	Range	Standard Error of the Mean ± SEM
May	9	15.49	12.3-19.6	0.73	3	10.43	4.1-16.3	3.33
June	17	15.65	9.3-21.3	0.84	7	13.2	4.8-21.4	2.17
July	15	18.4	12.0-23.9	1.01	10	14.35	6.4-19.5	1.38
August	6	28.9	23.9-36.3	1.76	3	24.55	18.4-33.0	4.37

The differences in growth rates between the two systems were significant at 5% level for the months of May and July, being higher for the on/off. The growth rates for the months of June and August in the two systems were not significantly different at 5% level. Because the treatment differences for June to August in Table 4.3 were confounded by the fact that many of the On/off pastures were grazed twice, the data were examined in more detail. The growth rates of individual paddocks for the 'on treatment' and the mean growth rates of consecutive groups of three 'on/off paddocks' (in both cases providing approximately ten days grazing) were plotted against time in Figures 4.IVa and IVb. Figure 4.IVa gives the growth rates during the first 21 days following grazing, and Figure4IVb the growth rates between day 21 and 42 following grazing. It is clear from Figure IVa that the growth rates were generally higher for the laxly grazed pastures. The average growth rates were 15.9 and 11.6 kg DM/ha/day respectively for the On/off and On treatments.

Figure 4.IVa: Growth rates of grazed pastures during the trial period (1st 21 days)

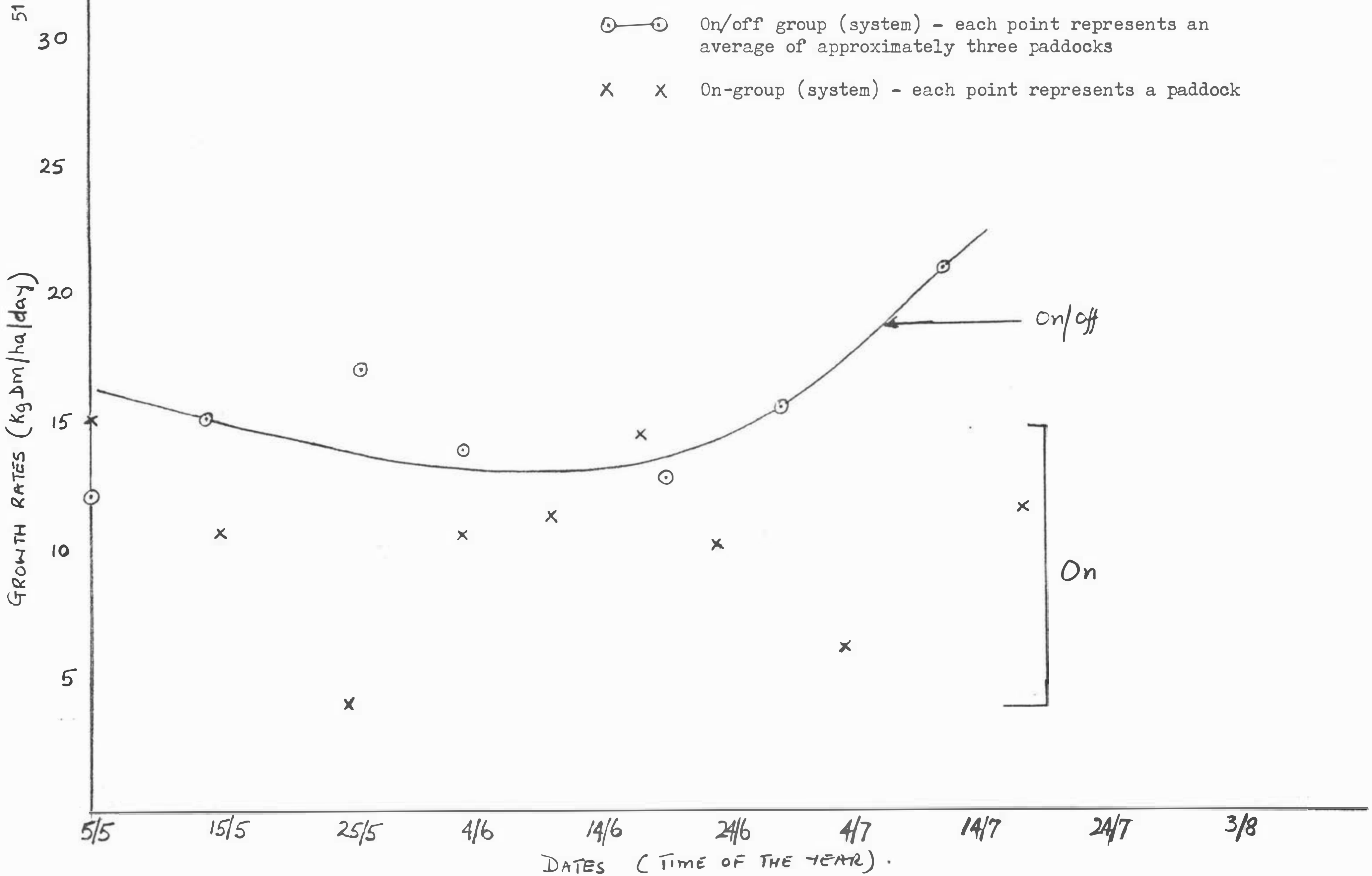
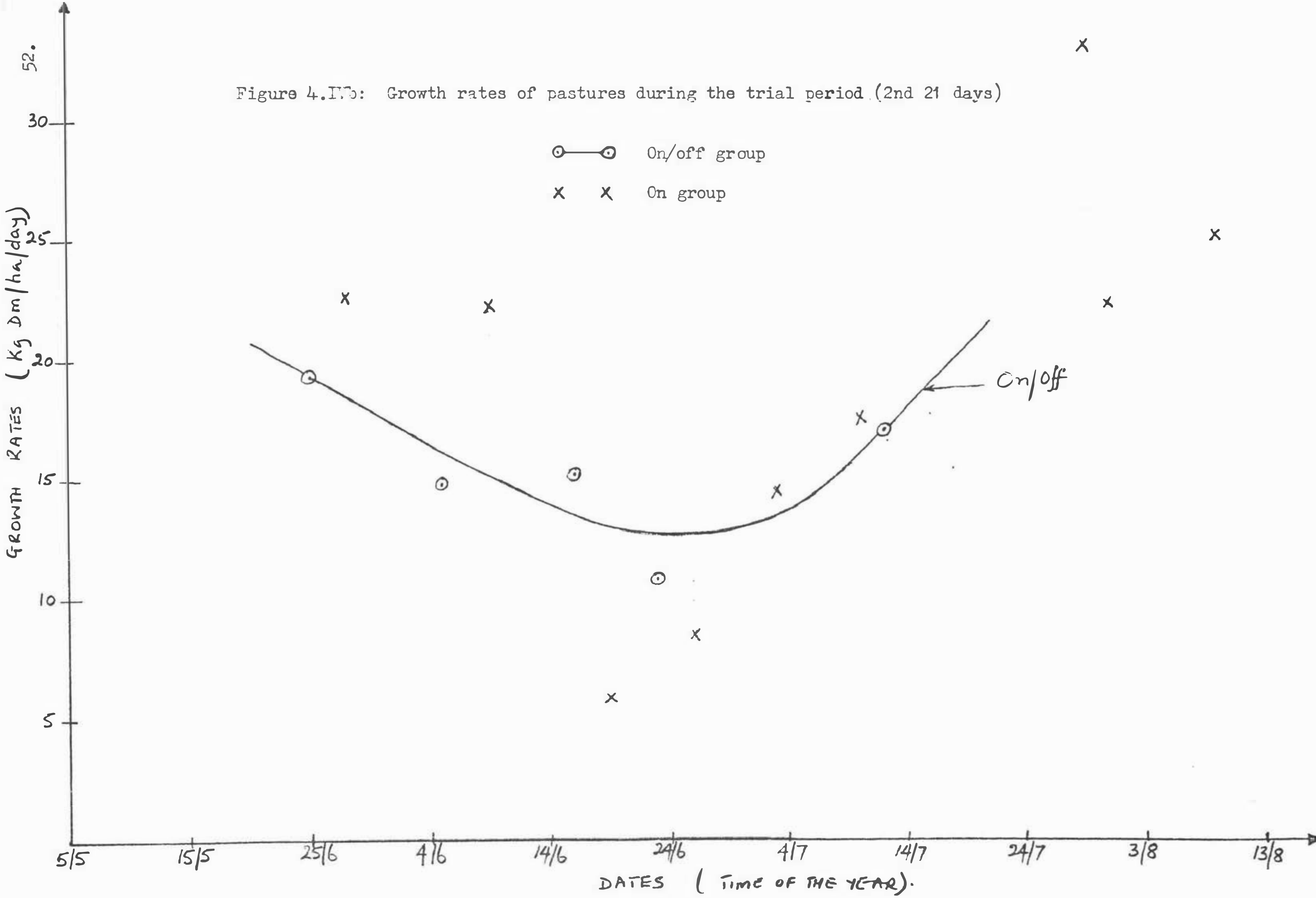


Figure 4.IIb: Growth rates of pastures during the trial period (2nd 21 days)



Rates of regrowth between days 21 - 42 (Figure 4.IVb) were not consistently different between treatments, but it is clear that the lowest growth rates occurred during late June or early July when the soil temperatures, which are illustrated in Figure 4.IVc, were at their lowest.

4:3:2 Pasture Growth Rates in relation to DM remaining following grazing

The whole of the data relating to pasture growth rates was divided according to time of the year (3 weekly periods) and the pasture DM at the beginning of each period. The mean growth rates and the range between paddocks within each mean are given in Table 4.4 extracted from Appendix IV.

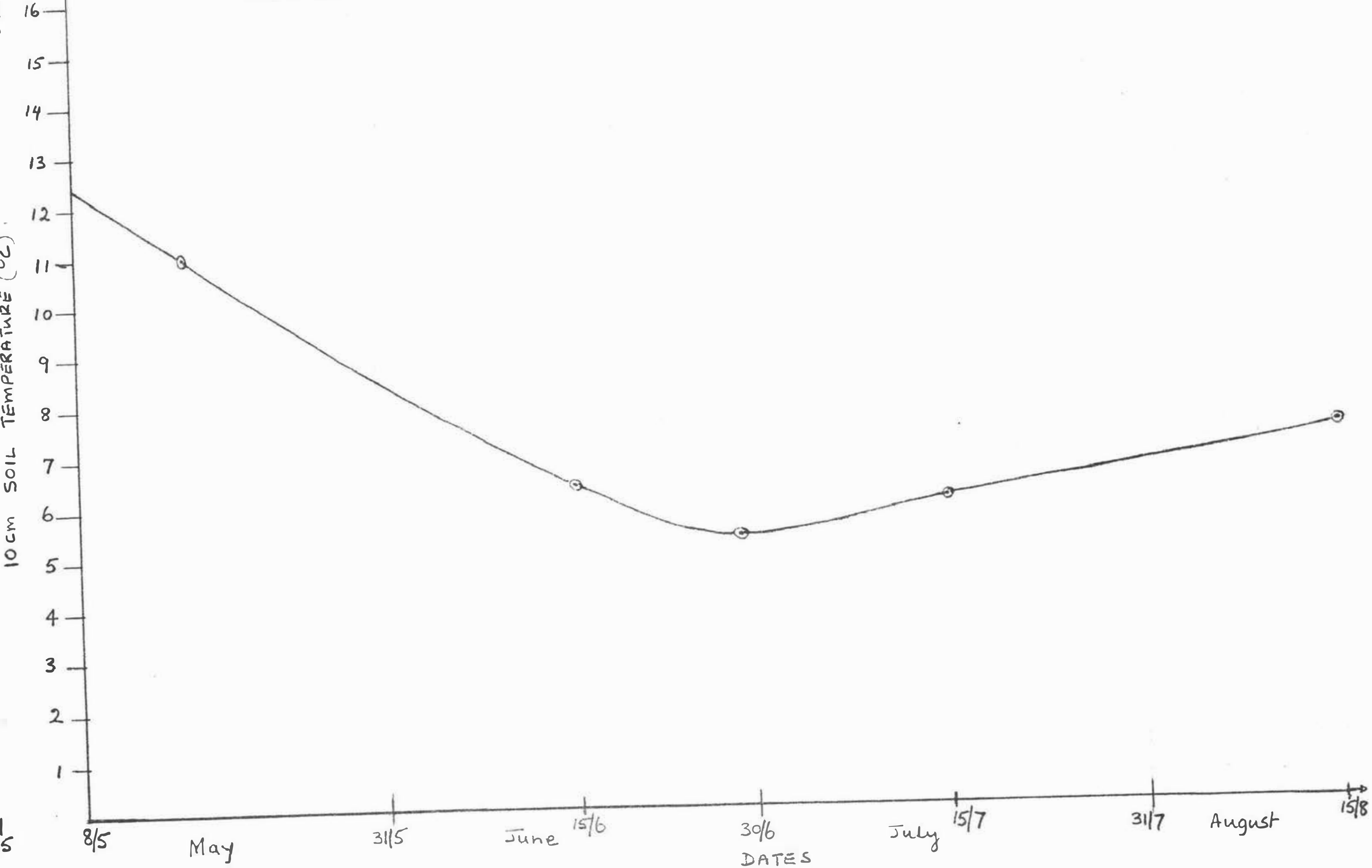
Table 4.4 - Pasture growth rates following grazing classified according to pasture DM present at the beginning of four periods of three weeks

DM Classification kg DM/ha	Dates 5/5 - 26/5	27/5 - 17/6	18/6 - 9/7	10/7 - 31/7
400 - 800	12.1 (4-16)	9.6 (4-12)	10.7 (4-15)	17.2 (6-24)
800 - 1000	15.1 (11-18)	16.7 (15-21)	15.8 (12.21)	18.7 (8-24)
1000 - 1200	16.6 (11-24)	16.1 (12-21)	15.7 (9-23)	18.6 (12-24)
1200 - 1400	17.6 (11-24)	16.5 (11-21)	14.0 (9-21)	17.2 (9-26)
1400 - 1600	[24]*	18.9 (12-24)	15.6 (10-21)	19.8 (12-27)
1600 - 2100	-	[24]*	-	26.3 (15-36)
2100 - 2600			[18.1]*	
2600				[10]*

*[ ] means for two individual paddocks which were 'long' at the commencement of the experiment.

Within each period, growth rates appeared to reach a value close to their maximum rate by the time the pastures reach 800 - 1000

Figure 4.IVc: 10 cm mean soil temperature (Winter 1975)



kg/ha. This Table also illustrates the effect of cold soil temperatures in reducing the maximum rates of growth reached during the 18/6 - 9/7 period.

The growth rates of two paddocks which were grazed in April, before the main experimental period started, are also given in this table [in brackets] and this illustrates the high initial growth rates and the reduction in growth rate that occurs when pastures come near to their ceiling yields (see also Figure 4.IVd).

4:3:3 Pasture growth rates and recovery in trodden and heavily pugged paddocks

Plates VIII (see page 43) and IX illustrate the effects of hard grazing, particularly when conditions were wet and cows have to stay for 24 hours in a 'break'. Clearly, there is a disappearance of pasture due to this effect of heavy pugging. In addition, when the grass was tall and wet the trampling and fouling effects were obvious and the grass to be harvested by cows was affected (see Plate XI for the on-group and XII for the On/off group for comparison).

After sometime (12 days +) observations were made to the portions which were heavily and moderately trodden as to whether the pastures were coming up. Plate X shows that in heavily trodden pastures there was hardly a sign of grass coming up while Plate XIII shows grass recovery in moderately trodden pastures. It is therefore clear that heavy pugging affected the rates of growth of pastures in the paddocks as shown in Figures 4.IVa and IVb (lower points on the graph, the on-treatment).

4:4 Intake and Production

4:4:1 The amount of feed consumed

Table 4.5a gives a summary of results of the amount of feed consumed per cow per day in each paddock for each group.

Plate IX: Two days after heavy pugging
(portion of a break: paddock 34)

Plate X: On-treatment: 12 days after heavy pugging
(portion of a break: paddock 32)

Plate XI: On-treatment when wet and grass tall trampling and fouling effects are obvious.

Plate XII: On/off treatment: cows in paddock 23 for the last day and they are in a satisfactory condition.

Plate XIII: On-treatment – Grass recovery 15 days after grazing in mid July.

Figure 4.IVd: Cumulative growth of pasture for 2 paddocks (Paddocks 11 and 17) which were not grazed during the trial period.

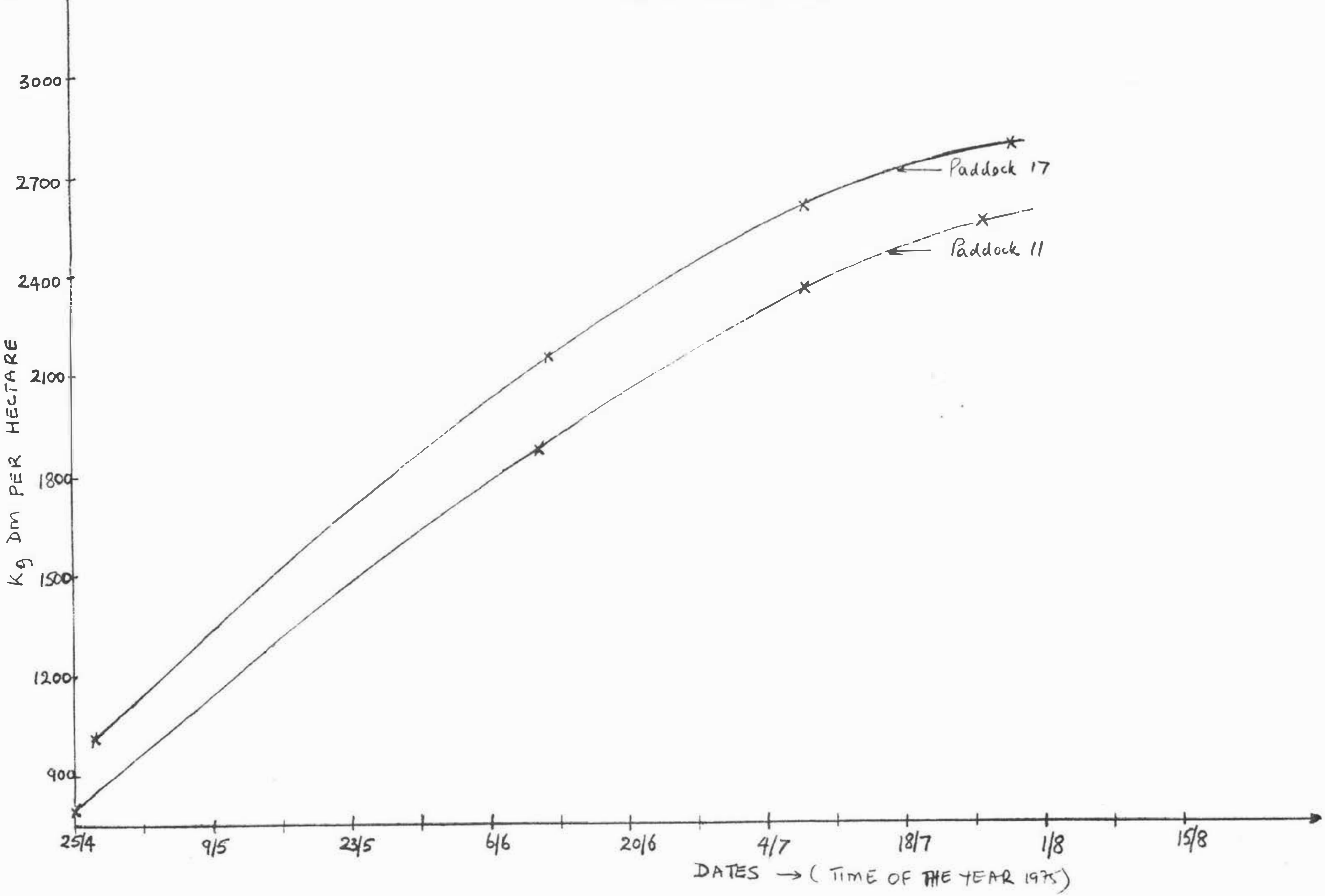


Table 4.5a - The amount of feed eaten by cows as grass and hay per paddock (kg DM/cow/day)

On/off Group

Paddock No.	Date of Grazing	Grass/cow per day kg DM	Hay/cow per day kg DM
21	30/4 - 2/5	3.435	1.08
31	3/5 - 5/5	1.63	1.62
40	6/5 - 8/5	3.28	1.62
33	9/5 - 11/5	3.26	1.08
42	12/5 - 14/5	3.8	1.62
23	15/5 - 17/5	2.6	2.16
26 a & b	18/5 - 21/5	3.13	2.27
30	22/5 - 26/5	3.34	2.16
22	27/5 - 30/5	3.82	2.7
1	31/5 - 1/6	3.01	2.16
5	2/6 - same	5.09	2.16
9	3/6 - 7/6	3.56	2.16
12	8/6 - 11/6	4.069	2.16
15	12/6 - 15/6	4.068	2.16
16	16/6 - 19/6	4.073	2.16
38	20/6 - 21/6	4.19	2.16
21	22/6 - 24/6	4.87	2.16
31	25/6 - 28/6	4.61	2.97
40	29/6 - 1/7	1.85	3.78
33	2/7 - 5/7	3.52	3.78
42	6/7 - 8/7	3.7	3.97
23	9/7 - 13/7	4.8	3.78
26a	14/7 - 15/7	6.79	3.34

Weighted mean intake of grass 3.7 kg DM

Table 4.5a - continued

On Group

Paddock No.	Date of Grazing	Grass/cow per day kg DM	Hay/cow per day
49a	30/4 - 10/5	2.02	4.32
39	10/5 - 19/5	2.34	3.84
32	19/5 - 29/5	2.425	3.242
41	29/5 - 5/6	2.44	3.24
34	5/6 - 12/6	3.37	3.24
24	12/6 - 19/6	4.61	2.70
8	19/6 - 27/6	5.15	1.62
27 a & b	27/6 - 6/7	4.49	1.62
28 a & b	6/7 - 14/7	6.46	1.19

Weighted mean intake of grass 3.8 kg DM

It is seen from Table 4.5a that the on/off group started with a high intake of grass with less hay, but as time progressed more hay was fed and the grass consumption remained at about 4 kg DM/cow per day. The increased level of hay feeding towards the end was found necessary because actual grass cover on the farmlet fell below target.

With the on-group, the intake of hay was higher to start with, but as the period progressed less hay was fed and more grass consumed. This procedure followed the plan laid out in the budget fairly closely (see Figure 4.IX).

The total amount of hay consumed throughout the trial period is given in Table 4.5b.

Table 4.5b - Total hay consumed on each farmlet (treatment)

On/off system (group)		On-System (group)	
Total hay	343	Total hay	400
Bales/ha	26.5	Bales/ha	30.88 (31)
Bales/cow	8.2	Bales/cow	9.52

The on-group consumed more hay (57 bales) for the whole period.

4:4:2 Relation between the measured daily intakes and live weight changes

Table 4.6a gives the results of live weight changes obtained for each group (treatment) and for mature cows and heifers. These average data were plotted on graphs as shown in Figures 4.V and VI.

The estimated daily average intakes of cows were worked out from Appendix V and these are presented in Table 4.6a as well. The daily average intakes and the weekly average live weight changes are plotted on graphs as shown in Figures 4.VII and 4.VIII, for the on/off group and the on-group respectively.

Figure 4.V: Mean live weight changes of the cows during the experiment

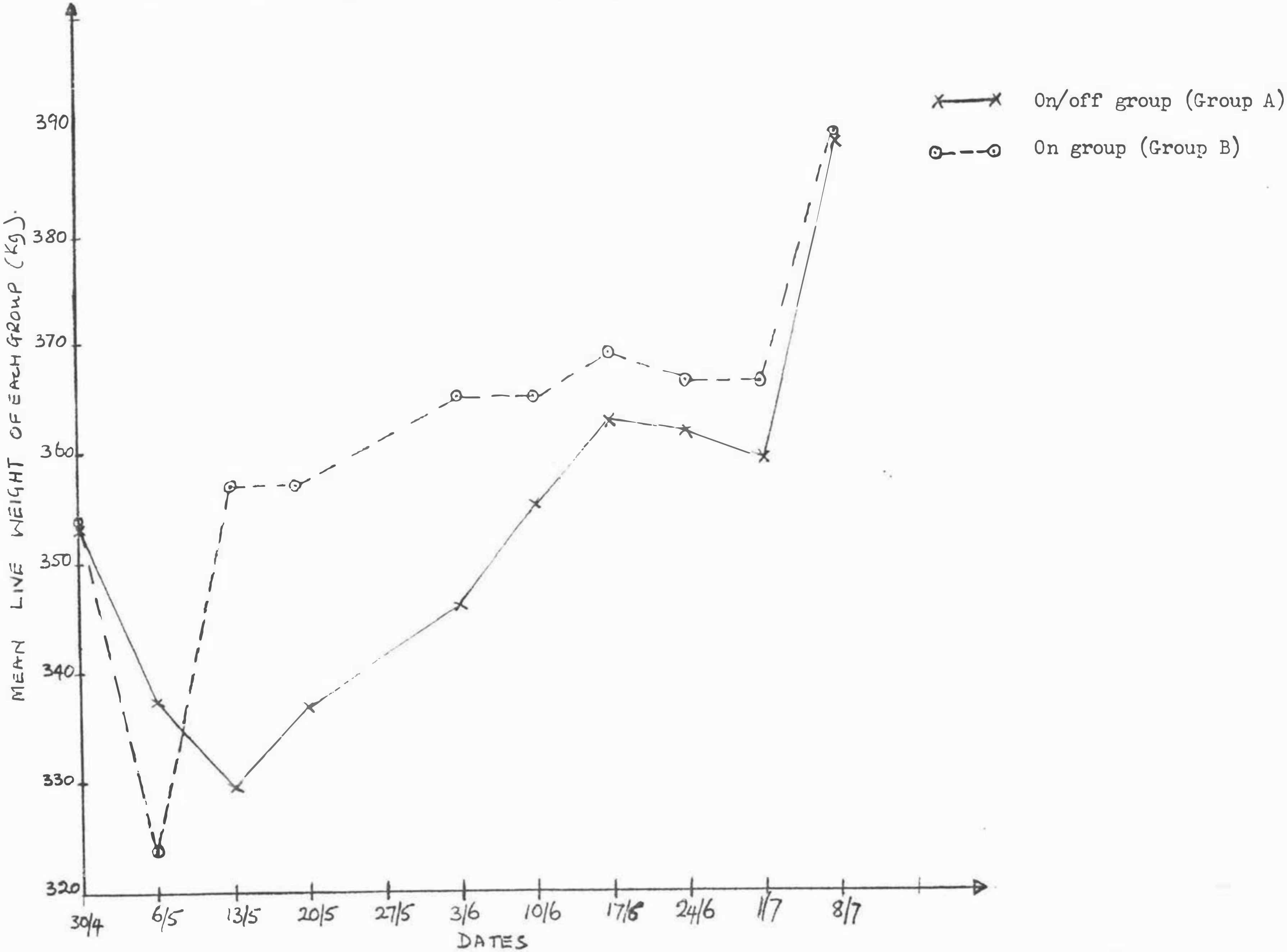


Figure 4.VI: Mean live weight changes of mature cows and heifers ('new', 'old' and 'all' heifers)

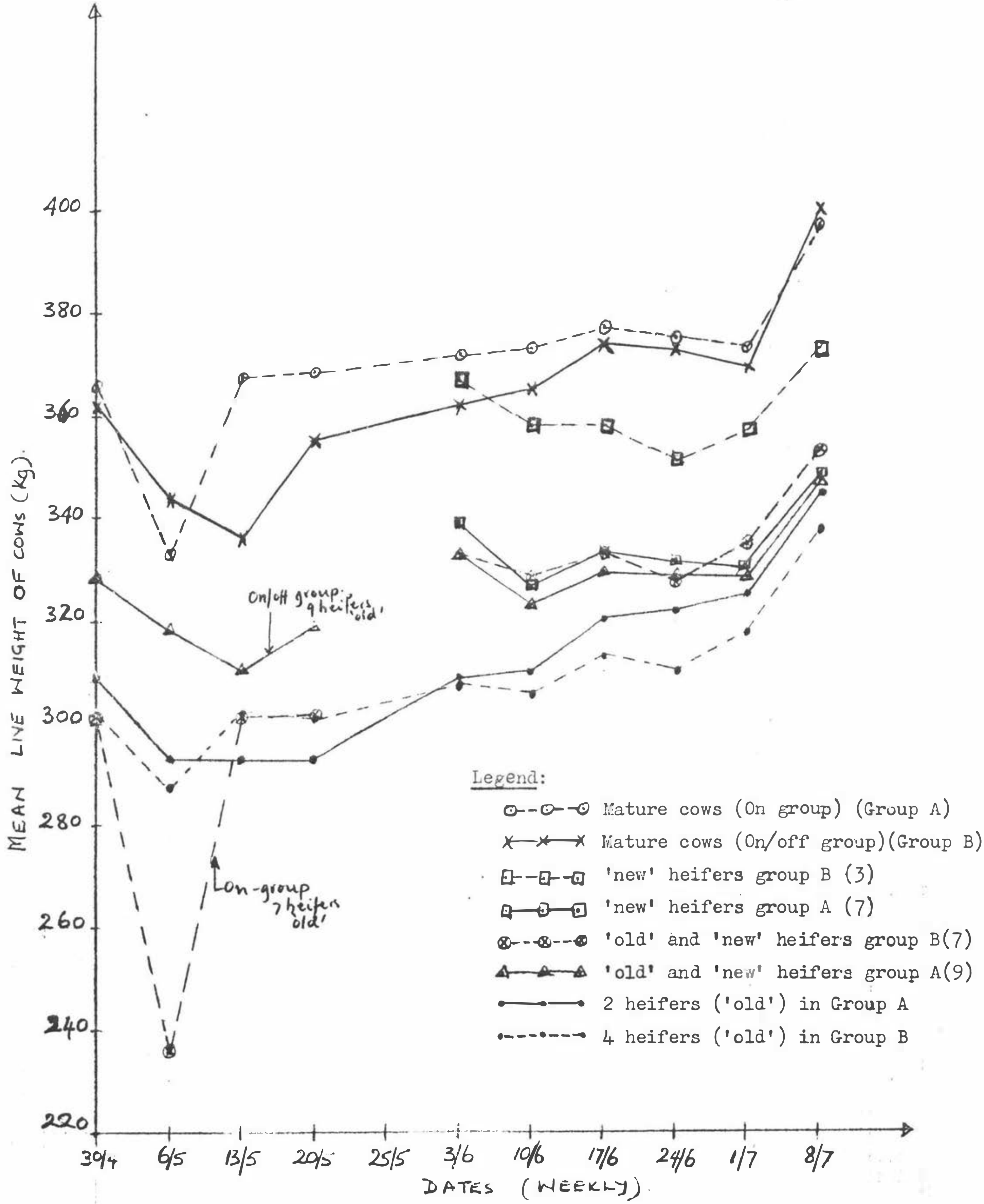


Table 4.6a - Live weight changes and measured daily intakes of cows.

Time in weeks	On/off group: Measured average intakes (kg DM/cow/day as grass	On/off group: Weekly Average Live weight (kg)			On group: Measured average intakes (kg DM/cow/day as grass	On group: Weekly Average Live weight (kg)		
		Mature cows	Heifers	Whole group		Mature cows	Heifers	Whole Group
0		362.1	338	353.4		366	301.5	353.9
0 - 1	3.612	344.3	318	337.5	5.04	332.9	236.2	323.9
2	4.39	336.2	310.3	329.5	5.76	367.8	301.0	357.2
3	4.49	354.8	319.2	337.2	4.89	368.4	301.5	357.3
4	4.95	*	*	*	4.70	*	*	*
5	5.4	362.3	† 332.7	346.2	4.71	371.8	† 333.4	365.4
6	6.097	364.7	† 323.3	355.5	5.64	373.0	† 328.3	365.4
7	5.57	372.9	† 329.9	363.4	6.5	376.9	† 332.70	369.5
8	5.97	371.5	† 328.9	362.2	6.3	374.9	† 327.9	366.8
9	5.76	368.6	† 328.6	359.8	5.7	373.2	† 334.6	366.8
10	6.047	400.9	† 347.3	388.8	6.6	397.4	† 353.3	389.8

About 20 cows have calved in all

* The weighing was not done due to strong winds (lead to innacuracy in the scale).

† 7 heifers in the on/off group and 3 in the on-group were replaced by 'newly' bought ones.

Hay was assumed to have 70% grass equivalence.

Figure 4.VII: Relationship between average live weight change and estimated average daily intakes for the on/off group

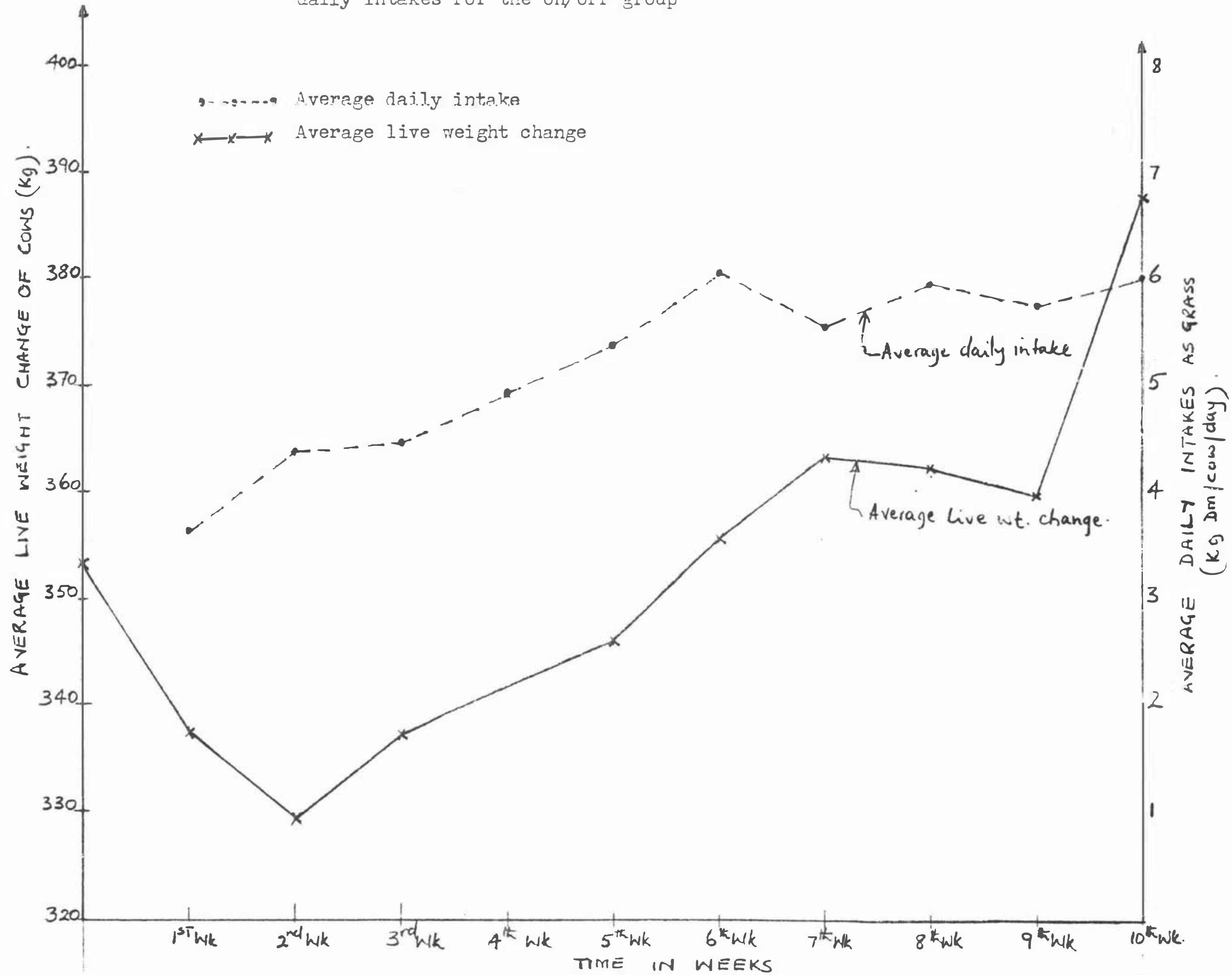


Figure 4.VIII: Relationship between average live weight change and estimated average daily intakes for the on group

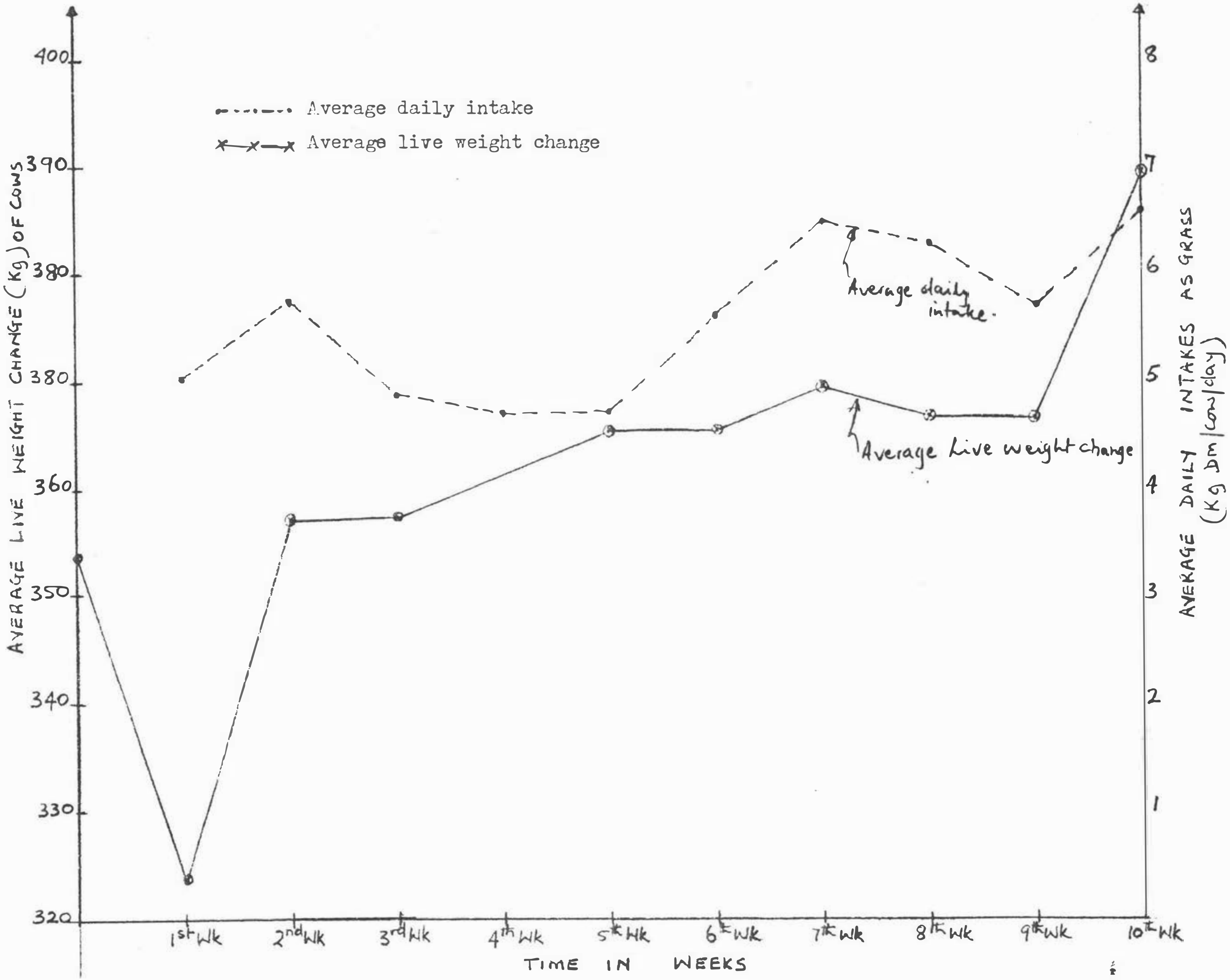


Table 4.6b - Weekly average live weight changes of 'old' and 'newly' bought heifers

Time in weeks	On/off Group		On Group	
	Average live weight of (2) two 'old' heifers	Average live weight of (7) seven 'new' heifers	Average live weight of (4) four 'old' heifers	Average live weight of (3) three 'new' heifers
0	309.1		302.04	
1	293.4		287.3	
2	293.3		301.9	
3	293.2		300.66	
4				
5	309.1	338.6	308.2	366.97
6	310.5	326.9	306.0	358.0
7	320.5	332.5	313.6	358.2
8	321.82	330.9	310.4	351.2
9	325.0	329.6	317.95	356.8
10	345.0	347.9	338.3	373.3

Tables 4.6a and b and Figures V and VI show the changes in live weight of both groups, and for mature cows and heifers respectively.

The change in live weight is about 35.4 kg for the on/off group and 35.92 for the on-group. For mature cows the change is 38.8 kg for the on/off group, and 31.4 kg for the on-group respectively. These data represent daily weight gains of 0.506 kg and 0.55 kg per cow/day for the on/off group, and 0.51 kg and 0.45 kg per cow per day for the on-group respectively.

The heifers ('old ones' remaining in each group) seemed to gain as much as the mature cows in both groups, that is 0.513 kg/cow/day for the on/off group and 0.504 kg/cow/day for the on-group.

The 'newly bought in' heifers seem to have maintained their weights.

Judged by eye, the condition of the cows was moderate, meaning that they were not underfed (Plate XII - On/off group spread over paddock).

4:4:3 Average Milk Production for the first three months of lactation

The average milk production of those cows lactating starting from mid July to mid October was recorded and the results are presented in Table 4.7.

Table 4.7 - Average Daily Milk production of cows (for three months)

Month and Date	Treatment A (On/off)		Treatment B (On)	
	No. of cows lactating	Average daily milk Production	No. of cows lactating	Average daily milk Production
As at 15th July up to 20th August	19	15.6 kg/cow	22	15.02 kg/cow
As at 20th August up to 24th September	33	13.4 kg/cow	33	13.8 kg/cow
As at 24th September up to 22nd October	38	14.6 kg/cow	35	14.86 kg/cow
As at 20th August up to 24th September	14 more cows calved	11.5 kg/cow	11 more cows calved	13.4 kg/cow
As at 24th September up to 22nd October	5 more cows calved	16.7 kg/cow	3 more cows calved	17.3 kg/cow

As seen from Table 4.7, the milk production was very similar for the two treatment groups.

4:5 Farmlet Comparisons

4:5:1 The amount of grass grown on each farmlet

The total amount of grass gorwn and the total amount eaten on each of the two farmlets was determined mainly by the cutting technique.

Table 4.8 summarises the results obtained from the two farmlets. This Table has been worked out from Appendix IV.

Table 4.8 - Total grass grown and consumed on the two farmlets between 29th April and 5th July 1975 (kg DM)

Growth in paddocks computed from growth rates data (i.e. those grazed in experiment)	Farmlet A (On/off)		Farmlet B (On)	
	Per hectare	Total	Per hectare	Total
	(12.95ha)		(6.91 ha)	
Amount grown (kg DM)	1234	15980	1173	8102
Amount consumed	776	10047	1340	9254
Increase in grass cover	458	5933	-167	-1152
Ungrazed portion of Farmlet B	0	0	(6.04 ha)	
			(a)(based on growth rate of 2 paddocks (see Figure 4.IVd))	
			1507	9102
			(b)(based on meter reading from the whole 6.04 ha)	
			1659	10035
Whole farm				
Total amount grown kg DM	1234	15980	(a) 1328	17204
			(b) 1400	18137
Total increase in cover	458	5933	(a)614	7950
			(b)686	8883

Taking (b) for farmlet B, the difference in favour of Farmlet B is 2157 kg or 13%

As can be seen in the Table, Farmlet B grew between 1224 kg and 2157 kg more than Farmlet A between April 29th and July 5th. The 2157 kg DM expressed in terms of growth rates is equivalent to 2.4 kg DM/ha per day or a 13% improvement over the growth rates made on the on/off farmlet.

4:5:2 Comparison of measured intakes and growth rates with Budgeted (Predictions) Estimates

Tables 4.9a and b compare the predicted and the measured estimates of growth rates of paddocks on the two farmlets. The same Table shows the predicted and the measured intakes of cows during the trial period.

The pasture growth rates were lower on both farmlets than those anticipated. Because of this, the quantity of hay that was provided to both groups was greater than the amounts budgeted for. In fact, the cover on the on/off farmlet became so low that (see Table 4.10) hay had to provide approximately 48% of the DM intake of the dry cows during July.

The total intakes of the cows on both groups expressed as grass DM were some 1.7 to 1.9 kg DM below the 'target' or budget intakes in July.

4:5:3 Comparison of measured and predicted grass covers on the farmlets

Table 4.10 compares the measured (grass meter readings) and predicted (budget) grass covers on the two farmlets. These results are also shown graphically in Figure 4.IX. The measured covers were lower than the predicted covers because of the lower growth rates obtained (see Table 4.3 and Tables 9a and b).

On examining the grass covers on individual paddocks in the month of July, a large number of paddocks of the on/off treatment were nearly even in pasture dry matter per hectare, while there was a wide variation in the on-treatment (Figure 4.X). It is also clear from Figure 4.X that nearly half of the on-farmlet was long (2700 kg DM per hectare +) while half was short ($<$1200 kg DM/ha).

Table 4.9 - Comparison of measured intakes and pasture growth rates with the values used in the Budget

Month	Growth Rates of Pasture (kg DM/ha/day)		Cow Intakes - Hay and Grass (kg DM/cow/day)							
			Predicted Requirements		Measured Intakes		Total Intakes			
							Predicted Requirements		Measured Intakes	
	Predicted Growth kg/DM/ha/day	Measured mean kg DM/ha/day	Grass (kg DM)	Hay (kg DM)	Grass (kg DM)	Hay (kg DM)	Grass + Hay	As Grass	Grass + Hay	As Grass
			a. On/off Treatment (Farmlet A)							
May	26	21.04	2.13	3.38	3.14	1.81	5.51	4.5	4.95	4.41
June	24	16.3	4.43	2.1	4.17	2.25	6.73	5.9	6.42	5.75
July	19.9	14.6	8.285	0.45	4.13	3.73	8.75	8.6	7.86	6.74
			b. On-Treatment (Farmlet B)							
May	26	22.9	1.01	4.5	2.27	3.8	5.51	4.5	6.07	4.93
June	23	18.3	4.40	2.33	3.98	2.7	6.73	5.9	6.68	5.87
July	19	12.5	7.84	0.90	5.87	1.38	8.74	8.6	7.35	6.94

Table 10 - Comparison of predicted and measured grass covers on the two farmlets obtained by curvilinear calibration curves (from Appendix III)

Dates	Farmlet A			Farmlet B		
	Predicted Cover without hay (kg DM/ha)	Predicted Cover with hay (kg DM/ha)	Estimated Cover using a grass meter (kg DM/ha)	Predicted Cover without hay (kg DM/ha)	Predicted Cover with hay (kg DM/ha)	Estimated Cover using a grass meter (kg DM/ha)
29/4/75	1120	1120	1175 (82.12)*	1120	1120	1192 (82.9)*
10/5/75	1256	1384	1213 (82.0)	1256	1415	1215 (81.9)
24/5/75	1416	1654	1488 (79.6)	1416	1734	1593 (78.6)
7/6/75	1529	1847	1574 (77.6)	1522	1919	1664 (75.6)
21/6/75	1596	1977	1662 (76.6)	1564	2052	1793 (73.98)
5/7/75	1599	2012	1576 (76.97)	1439	2073	1855 (75.2)
19/7/75	1486	1899	-	1321	1980	-

*(   ) Mean of means of meter readings - 17 paddocks

Figure 4.IX: The anticipated 'grass covers' as compared to the measured 'grass covers'

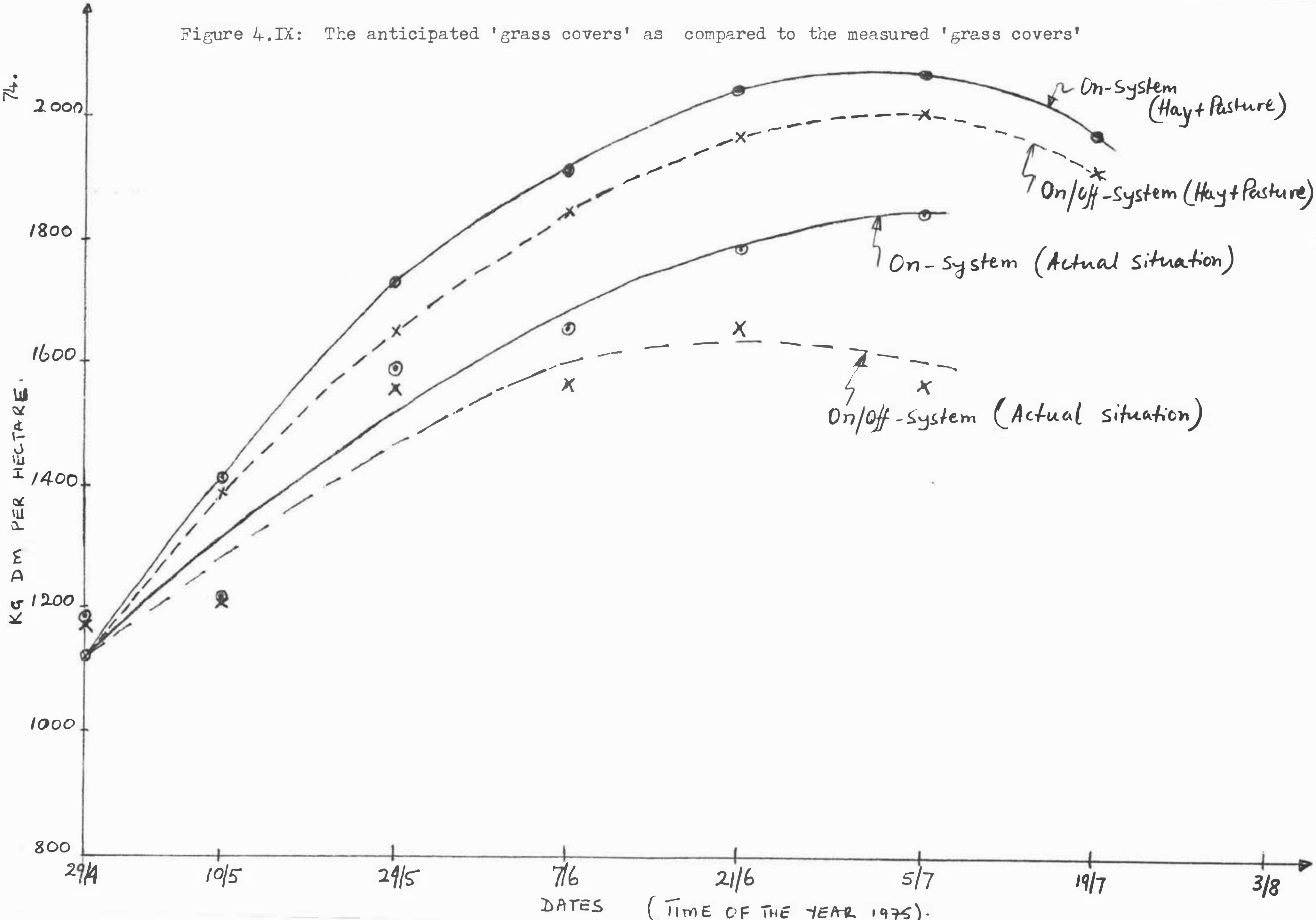
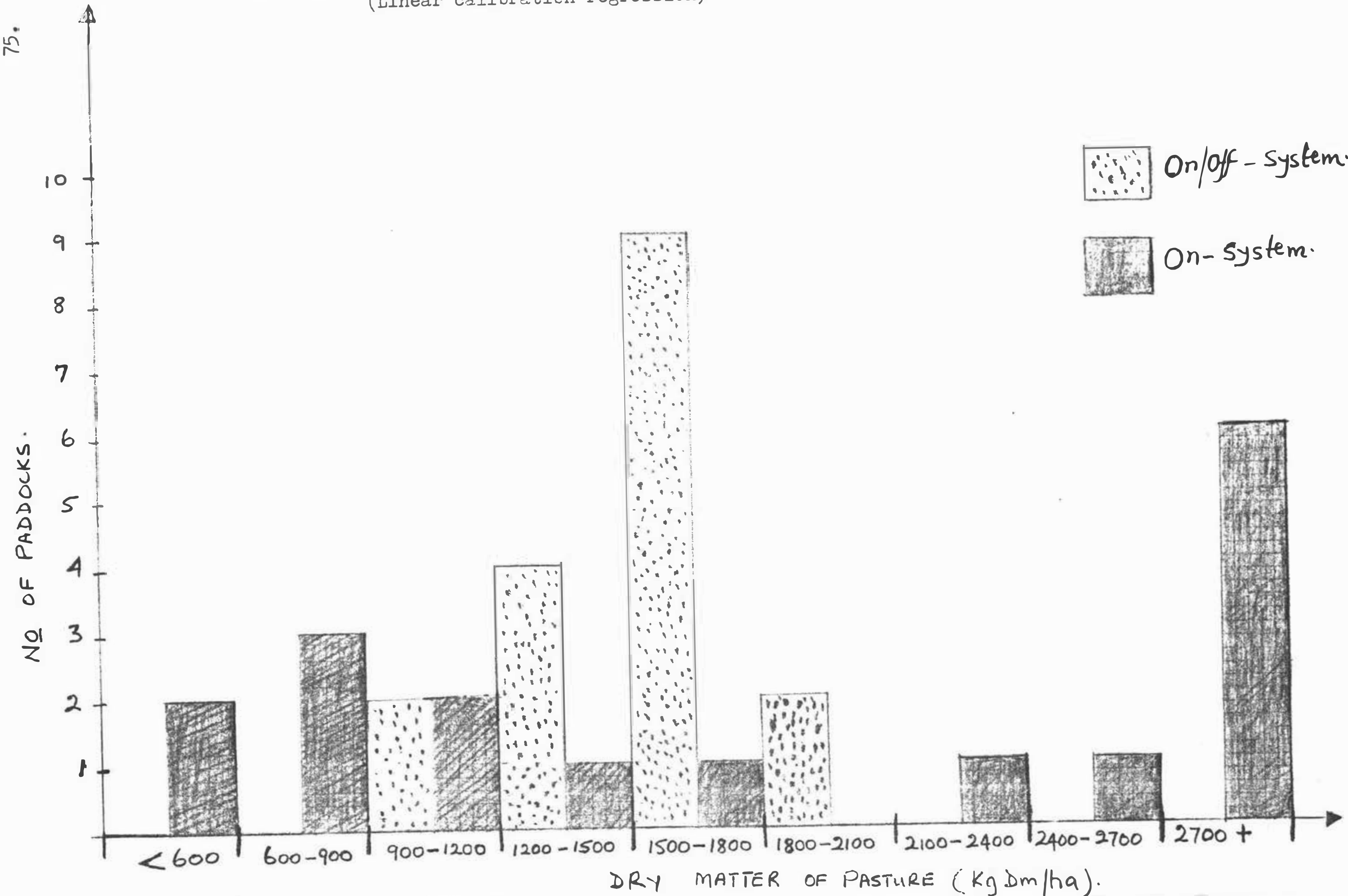


Figure 4.X: Grass cover on individual paddocks determined on 5.7.75 using the grass meter (Linear calibration regression)



4:5:4 Pasture Damage

Pasture damage through pugging and fouling occurred on the two farmlets, but it was more noticeable (observable) on the hard grazed pasture, particularly when the weather conditions were wet (see Plates VIII, IX and XI). The Table below presents the area which was pugged by the on-group.

Table 4.11 - The area pugged by the on-group (only the paddocks pugged heavily are presented - extracted from Appendix V)

Paddock No.	No. of breaks in each paddock	Area pugged ha	
44a	10	0.045 (½ break)	
39	9	0.05 (½ break)	
32	10	0.186 (2 breaks)*	severely pugged
41	7	0.103 (1 break)*	= 0.417
24	7	0.128 (1 break)*	= 3.2% of total area of farmlet B
27 a and b	9	0.116 (1 break)	
28c	5	0.272 (1 break)	
		0.9 ha	

.900 = 7% of total area of Farmlet B

Half of this area, 3.2%, was severely damaged and may have to be reseeded the following spring because there was virtually no sign of grass in some breaks 1½ months after spelling.

CHAPTER 5

GENERAL DISCUSSION

5:1 The validity of the techniques used to measure dry matter yields

The Cutting Method: The cutting technique is said to be more accurate than other methods, e.g. visual appraisal method, in determining the dry matter yield of pastures on farmlets (Harlan, 1956), and if repeatedly done, experience is acquired. This method was used in determining the amount of pasture present before and after grazing on paddocks. In addition, the method was used to estimate the amount of herbage consumed by cows in each paddock, hence each farmlet, and the regrowth of pasture occurring after grazing. The measurements obtained using this technique may have been affected by the following:

(a) The difficulty of clipping the grass close to ground level, particularly on an uneven surface where pugging was severe. This probably led to inaccuracies in the estimates of dry matter yields of pastures.

(b) Soil particles and dead matter from the surface of the soil may have been included into the clipped grass samples and if the grass samples were not properly washed, may have led to errors in the estimate of dry matter yield.

(c) In windy conditions, some grass may have been blown away, and this may have led to underestimation of the dry matter yield. Grass could have been clipped when there was no wind, but this was difficult to do since cows were to graze the paddock or break the next day.

(d) Some variation due to operator himself may have led to variation in pasture dry matter on farms.

Despite these shortcomings, the method was the main one used for estimation of dry matter in paddocks before and after grazing. The method however is time consuming and very laborious, therefore it is not a method which farmers can easily adopt unless they have to employ some persons to do the work for them. A number of steps are involved in determining the DM of pasture, that is, cutting, washing, drying and weighing, so that the necessary facilities have to be available, for example, the oven for drying the grass, and this may not easily be so for a number of farmers.

Visual Technique: Visual assessment of the dry matter yield was carried out daily with the cutting technique just to see how good the eye was. Hutton and Parker (1973) obtained a good correlation (0.82) when this method was compared with the cutting technique. In this trial, when the two techniques were compared (cutting vs visual - Appendix VII), the mean difference in DM before grazing was about 146 kg DM/ha on the on/off system, and 45 kg DM/ha on the on system respectively, in favour of the cutting method. The variation between methods within paddocks was very large. However, for quick assessment of the whole farm this could be a useful method.

The Massey Grass Meter: This instrument was calibrated using the cutting technique therefore the problems associated with the cutting technique (see above) could have led to the same variation in the meter readings. In addition, the meter itself was not consistent in determining the amount of DM in paddocks or farmlets, since a meter reading of say 70 in May did not give the same dry matter measurements in June or July. This led to the need for separate calibrations for each month. Some reasons are suggested for this inconsistency in the grass meter, namely:

(1) Species composition in the sward may differ (and hence height and density) and these give different total dry matter yields on paddocks (Parker, 1973).

(2) The yield of dry matter determined in paddocks with patches of long and short pasture may be inaccurate through chance factor but this problem is not likely to be important provided a large number of random readings are obtained. In this study, fifteen samples were taken from each paddock and the coefficients of variation of the meter readings

within paddocks were generally in the range 2.0% - 10.8% (mean 6%).

(3) Unfortunately the design of the grass meter was such that a bias in the results was possible in that the plate could not fall below the bottom of the centre rod which sits on the ground. This means that the effect of the small hollows (e.g. hoof prints) and knobs will not be cancelled out. This bias would have had most effect on the readings taken following grazing, especially if the ground was pugged and would have the effect of overestimating the amount of DM that was actually present. This may account for the fact that the calibration curves did not always go through the origin (90 on the meter scale).

(4) It is possible that a considerable amount of dead grass arising from the material ungrazed during the summer and present in the 'bottom' of the sward may decay during the May/June period. This may have also contributed to the observed tendency of the calibration curve to progressively change in slope and intercept (see Table 4.1 of results).

(5) During windy conditions, long grass may lodge and instead of the meter giving higher readings lower meter readings are recorded and this would clearly lead to errors in the estimation of the DM present.

Despite the above disadvantages mentioned, the grass meter was considered useful in assessing the grass cover on the two farmlets. Table 4.10 and Figure 4.IX of results of 'covers' obtained for July using the grass meter compare very well with the grass 'covers' (Table 4.8) obtained by the cutting method (i.e. 1576 vs 1578 kg DM/ha for the on/off system and 1855 vs 1734 kg DM/ha or 1855 vs 1806 for the on-system respectively).

5:2 The Grass Budgets

The grass budgets drawn up at the beginning of the experiment served a useful purpose since within one to two weeks it became clear that growth rates were lower than expected and 'grass cover' on both farmlets was well below the anticipated levels. This led to some changes in the amount of hay that had to be fed to meet herd requirements.

A revised budget should probably have been undertaken before the end of May which may have indicated that larger increases were needed in the quantities of hay being fed to the on/off group. Because this reassessment was not made, this group had to be fed more hay at the later stages of pregnancy, than what was perhaps desirable (see Section 5:5 of this discussion).

5:3 Pasture Growth Rates

The data on pasture growth rates are of interest from two points of view. The first is the rate of regrowth following grazing and the importance of such factors as intensity of grazing (treatment effects), stage of growth, soil and climatic conditions which have influence on rates of grass growth. The second important aspect is the growth rates of farmlets as a whole and because these were found to be affected mainly by the proportion of each farmlet 'grazed' rather than 'ungrazed' (during the May - July period) a discussion of this aspect is made separately.

5:3:1 Growth rates of pasture following grazing

The effect of intensity of grazing on growth rates: This effect is clearly indicated in Figure 4.IVa, which shows that the growth rates during the first 21 days were considerably lower for the on-group than for the on/off-group (Means = 11.6 kg DM/ha per day vs 15.9 kg DM/ha/day for the on-group and on-off group respectively). This is in general agreement with the classical work of Brougham (1956a) who observed that the height of defoliation of pastures is important in the rate of growth of pasture. His treatments were defoliations to heights of 1" (2.54 cm), 3" (7.62 cm) and 5" (12.7 cm) respectively. He noted that the 1" treatment took nearly 24 days to intercept 95% and over of incident light. The 3" (7.62 cm) and 5" (12.7 cm) treatments took 16 and 4 days respectively to intercept all incident light. In Table 4.4 of results, this fact is clearly seen for the two paddocks which were not grazed during the trial period.

In this trial, the hard grazed pastures (Table 4.4 of results) took a longer time to acquire maximum growth rates than the leniently grazed pastures (21 days). The growth rates in the second 21 days were nearly similar in the two treatments (Figure 4.IVc), and in fact in some cases they were lower for the leniently grazed pastures. The possible reasons for the low growth rates in the second 21 days may be due to deterioration and decomposition of tissues of plants due to increased rainfall and these could not be offset by the formation of new tissues (Brougham, 1957). Secondly, the temperatures may have been low enough, as suggested by Brougham (1956b), in the late autumn, winter and early spring to limit pasture growth rates. This suggestion held true in this trial since temperatures started falling in May (12^{o}C), reaching a minimum in July (7.7^{o}C) - Appendix VI. Thirdly, the competition effect of plants for nutrients within the environment could have been taking place, hence only those plants capable of competing were able to grow.

The effect of treading: Edmond (1963, 1966) observed a decrease in yield of pasture when the pasture was trodden by sheep. The low yield was attributed to low growth rates which are brought about by this treading effect. Treading damages the plant cells and hence lowers the recovery rate of plants. This effect becomes worse when the weather conditions are wet and the pastures are grazed hard (Plates VIII - Methods and IX of results). The low growth rates obtained in the grazed portions (Table 4.3 of results), particularly with the on-system, may partly be due to this treading effect. In the heavily pugged portions, there was no trace of grass coming up for quite a while (see Plate X of results). About 70% of the total area of the on-group was to some extent pugged and about 3.2% of this area may have needed reseeding the following spring. Parker and Willis (1973) considered 1% as severe damage necessitating oversowing in volcanic soils of Taranaki area after wintering cows. So 3.2% was reasonable under such heavy soils when the wet and cold weather of 1975 are considered.

5:3:2 Pasture growth rates on a farmlet basis

The average growth rates of pastures were generally low on the two farmlets (Tables 4.9a and b of results). Holmes and Wheeler (1975) measured an average growth rate figure (No. 3 Dairy Unit 1971-74) of

17 kg DM/ha/day for July. This figure is higher because the climatic factors were more in favour of high pasture growth rates. The figures of 14.6 kg DM per ha/day and 12.5 kg DM/ha/day obtained in this trial for July for the on/off and on-systems respectively, compare reasonably well with the figure of 11.2 kg DM/ha/day obtained by Brougham (1959b). The low growth rates obtained were partly due to climatic factors and partly to treading effects on the on-treatment as discussed above.

The growth rates of pastures for the on/off system seemed to be lower than the growth rates of pastures for the on-system in the months of May and June (See Table 4.9 a and b of results.) The reason for this is that only half of Farmlet B has been grazed, while all of Farmlet A was already grazed and the cows were in fact in the second rotation. Thus, most of the averaged growth rates in June would be regrowths for the on/off system, while the average growth rates for the on-system would be those from the 'grazed' portion and the 'ungrazed' portion of the farmlet. The fact that the growth rates were lower for the on-system than for the on/off system in July shows that the 'grazed' portion was low in growth rates and the 'ungrazed' portion may have been reaching its maximum ceiling yield (growing at reduced rate - Table 4.4 of results).

Although the growth rates of pasture were generally low for the two systems of management, it is evident that the growth rates of pasture for the first 21 days were much lower where the effects of defoliation and treading were severe. These effects coupled with wet weather and where soils are heavy may lead to severe pasture damage and in effect disappearance of pastures. It is therefore evident that hard grazing is not desirable under the above mentioned conditions.

5:4 Intake and animal production

The average daily intakes of cows in both groups as judged from Table 4.6a were satisfactory. The fluctuations obtained in these daily intakes from week to week were due to difficulties in allocating exactly the desired amount of feed for the cows. This was most difficult to achieve when providing the first break or two in a new paddock. The on/off cows received more hay late in the dry period because the cover on the farmlet was getting lower (Table 4.5a and Table 4.9a of results).

The average daily intakes of about 6 kg DM/cow (as grass equivalent) in the last 1 - 2 weeks before calving compares reasonably well with the predicted requirements of the animals (page 13 in the review of literature). This intake of 6 kg DM/cow/day was to cover for maintenance, pregnancy and some improvement in body condition (0.3 kg/cow/day) for a 350 kg cow.

Live weight changes: The large fluctuation in weights observed in the first week of the experiment (Figures 4.V and VI) in both groups but more pronounced in the on-graoup may have been due to (a) cows adjusting themselves to the experimental treatment, (b) lack of water, particularly to the on-group which had more hay to start with, thus affecting their intake. When water was supplied all the hay was eaten. The heifers seemed to have lost more weight than the mature cows, particularly in the on-group. Other variations in live weight changes after the first week of the experiment could be due to variations in 'gut fill' (Hutton, 1962; Wallace, 1961; Hutton and Parker, 1973).

If the minor fluctuations in weight are ignored, and it is assumed that the weight change over the 70 days of the trial is the live weight gain of cows, then the cows were gaining at a rate of $\frac{35.4}{70}$ kg/cow/day for the on/off group and $\frac{35.92}{70}$ kg/cow/day for the on-group. Thus, on the average, cows were gaining at a rate of 0.5 kg/cow/day in both groups. This live weight change of 0.5 kg/cow/day is approximately equivalent to the weight gain being made by the foetus and its associate structures.

Hutton and Parker (1973) in their trial obtained an increase in weight of 0.9 - 1.0 kg/cow/day for a 330 kg cow in the last four weeks of pregnancy and 4.8 - 5.8 kg pasture DM was required to promote this live weight gain. Grainger et al (1975) in Australia obtained the same live weight gain (0.9 kg/cow/day) in the last five weeks of pregnancy for cows weighing 345 kg and consuming 6 kg DM/day as grass or 2 kg DM pasture + 5.3 kg DM hay. McDonald et al (1973) gave a weight gain of 0.8 kg/cow/day for a 500 kg cow in the last six weeks of pregnancy. The energy content of these feeds was assumed to be 12.13 MJ ME/kg DM (Hutton and Parker), 10 - 11.3 MJ ME/kg DM (Grainger et al), and 10.9 MJ ME/kg DM (McDonald et al).

In this trial, a weight gain of 0.7 - 0.9 kg/cow/day was obtained for the last four weeks of the ten week experimental period (Table 6.6a of results), and the consumption of feed was approximately 6 kg pasture DM. The energy in grass was assumed to be 11.3 MJ ME/kg DM which is slightly lower than the figure quoted by Hutton and Parker (1973). These results compare reasonably well with those of Hutton and Parker (1973) and other workers. In fact, the cows were in satisfactory condition at the time of calving as judged by eye (Plates XII of results).

Milk production: When the experiment was stopped, about twenty cows were lactating in the two groups. By August 20th about half of the cows in each group were lactating and a number were yet to calve.

The daily milk production of cows from each group was similar (Table 4.7 of results). This was expected to be so since the cows were fed at very similar levels prior to calving and there was also no real difference between groups in body weight and condition.

The cows calving in September though seemed to have lower average milk production than the cows which calved earlier or in October. This low milk production could have been due to shortage of feed in early spring, but as time progressed more feed became available.

5:5 Farmlet comparison

The average pasture growth rates assumed for use in the budgets proved to be far too high. Low growth rates on both farmlets were experienced in the winter of 1975 and these were due to climatic factors - low temperature, much rainfall and low radiant energy, and the effects of defoliation and treading which were more pronounced with the on-system.

Because of low growth rates of pastures, 343 bales of hay were fed to the On/off group, which was six more than was budgeted for. The on-group managed to utilize 400 bales of hay which was 40 bales less than in the budget. However, it should be noted that if the experiment was continued until the end of August as planned in the budget, it may be that more hay would have been fed to the on-group, since half of the farm was fairly short at the time of stopping the experiment.

Although neither of the systems achieved the target of pasture cover as planned, the on-system seemed to have followed the budget fairly closely (Figure 4.IX of results). In addition, the on-system (Farmlet B) grew more feed than the on/off system (Farmlet A), that is 13% improvement. This improvement was due to the half of the farm which was not grazed during the trial period. In fact, if only the grazed paddocks were considered the on/off system (pastures) grew more dry matter (Table 4.8) especially during the first 21 days of regrowth (Figure 4.IVa).

Other advantages which accrued from the on-system (Farmlet B) were:

1. There was less labour of moving the cows from break to break or from paddock to paddock.
2. There was less transfer of fertility from paddock to yards and races since cows had to stay in an area for 24 hours, therefore most of the faeces and urine were deposited in the same area.
3. When the weather was good a high proportion of the pasture grown was harvested (see Plate I - Methods).

The disadvantages of the on-system were as follows:

1. A large proportion of the farm (half of the farm - see Table 4.8 of results) was not grazed during the trial period. In this case the

pasture got long and the lower leaves started rotting. This situation of the pastures getting long and starting to decompose and decay may have reduced the quality of the pasture as a whole (Smetham, 1973; Kirton, 1967).

2. Half of the farm was short (see Figure 4.X of results) and this would not be suitable for use by milking cows until late August or September because they need to graze paddocks having 1500 - 1700 kg DM/ha.
3. Heavy pugging was evident on the grazed portion of the farm, particularly when the soil was wet.
4. A number of electric fences have to be erected on the paddock to ration the grass to stock (see Plate I - Methods).

On/off system (Farmlet A): Although this farmlet grew less feed, it was fairly even in pasture cover present in each paddock (Figure 4.X - 1500 kg DM/ha) at the time of stopping the experiment, and this may have led to faster growth rates during the spring. Other possible advantages of this system were:

(a) Heavy pugging did not occur in the paddocks, therefore less damage on pastures was evident.
(b) The whole of the farm was grazed during the trial period and therefore the grass grown (regrowth) was nutritious (high nutritive value). In addition there was likely to be less decay of tissues, for example lower leaves, due to maturity of the pastures.
(c) Less fences were used to ration the feed to stock.

The disadvantages of the system were:

(a) It involved more labour of shifting cows to and from the paddocks, and washing the conrete race.
(b) Fertility transfer from paddocks was inevitable since cows spent between $20\frac{1}{2}$ hours and $21\frac{1}{2}$ hours on a concrete race.
(c) The wintering barn or race cost money and this must be accounted for in this system.
(d) When growth rates are lower than expected, the on/off system may lead to difficulties of maintaining adequate 'cover' on the farm (approx.

200 kg DM/ha was the difference between the farmlets as at 5.7.75) hence may be a risky system to adopt under such conditions. However, better ways may be found to predict growth rates or measure farm 'cover' which would reduce this risk factor.

While each system had its own advantages and disadvantages, it seemed to me that if the weather was good to favour the growth rates of pastures, the on/off system would have been the best since the soil-plant- animal eco-system would have been worked out fairly well rather than extremes of cases which are observed with the on-system. It is therefore suggested that a system which incorporates a combination of the two systems of management could be the best because the advantages of both systems may be gained and there will probably be no disadvantages. For example, the cows could be removed from pasture whenever significant amounts of rainfall, whereas at the other times the cows would remain on pasture. In addition, the eco-system of soil-plant-animal may be maintained fairly well without serious shortcomings in any one of the systems.

SUMMARY

Two 12.95 hectare farmlets each carrying 42 cows were used to compare two winter grazing management systems, namely (i) the on/off-system (A) in which the cows were allowed to graze on pasture for a limited period each day, and were then removed to spend the remainder of the day on a concrete area on a race and fed hay to meet the calculated requirements; and (ii) the on-system (B) in which cows were to remain on pasture for 24 hours and fed hay as well to meet the calculated requirements. The grazing pressure adopted was approximately 160 cows/ha/day and 391 cows/ha/day for the A and B farmlets respectively.

Grass growth rates were measured in the context of the two systems and grass budgets were used as an aid to meeting the requirements of the cows with pasture or hay. The maximum rate of growth obtained following grazing varied between the two systems, being higher for the on/off system (i.e. 15.5 kg DM per ha/day in May to 28.9 kg DM/ha/day in mid-August and 10.4 kg DM/ha/day in May to 24.6 kg DM/ha/day in mid-August for the on-system). When the growth rates were considered on a farmlet basis ('grazed' and 'ungrazed' portions), the growth rates varied between approximately 21.0 kg DM/ha/day in May to 14.6 kg DM/ha/day in July for the on/off system, and 22.85 kg DM/ha/day in May to 12.5 kg DM/ha/day in July for the on-system respectively. This variation obtained in growth rates of farmlets, being higher for the on-system to start with, is explained by the fact that only part of Farmlet B was grazed while all of Farmlet A was grazed, thus the growth rates obtained on Farmlet A were mainly regrowths.

The grass growth rates following grazing of laxly grazed paddocks were, on the average, 29% higher than the hard grazed pastures during the first 21 days of regrowth and after that the rates were almost similar. This advantage to the on/off system (A) was, however, negated because a greater proportion of the whole farm was grazed (albeit laxly) which reduced the growth rates of Farmlet A as compared with ungrazed

portion of the intensively grazed farmlet (B).

At the end of the experiment, the available pasture was distributed very differently on the two farmlets. On Farmlet A, the pastures were of fairly similar heights and contained about 1580 kg DM/ha, whereas on Farmlet B some paddocks were either very long or very short, but the average cover was about 1800 kg DM/ha.

Each system has shown its advantages and disadvantages as discussed in the text. While there was no clear cut advantage to one or the other system obtained, it is considered that an intermediate grazing pressure (say 270 - 280 cows/ha/day) to those chosen may give better results. Alternatively, some combination of both systems depending on climate (temperatures, rainfall and radiant energy) and soil conditions which favour the growth rates of pastures should be further investigated.

Appendix I: Experimental Layout

NO.3 DAIRY UNIT

N

Campus

Group A. On-off lax grazing 32 acres

Group B. Continuous grazing 32 acres

APPENDIX II: Predicted Feed Budgets for two Farmlets

Estimated Feed Budget for Farmlet A (On/off Group)

The budget is prepared using the following information:

(1) Grass Growth Rates and Cows Requirements

Month	Growth Rates (Holmes 1974)	Cows Requirements (Davey 1974)
May	26 kg DM/ha/day	4.5 kg DM/cow/day
June	24 kg DM/ha/day	5.9 kg DM/cow/day
July	19.9 kg DM/ha/day	8.6 kg DM/cow/day
August	28 kg DM/ha/day	9.7 kg DM/cow/day

(2) Cover as at 30th April by visual assessment was 1120 kg DM/ha.

(3) Cows expected to calve in mid-July-August and early September.

(4) The number of cows - 42, and the area is 12.95 ha (32 acres). Thus the stocking rate = 3.25 cows/ha.

In Table form:

Month	Grass Grown		Grass Eaten	
	kg DM/ha/day	kg DM/month	kg DM/cow/day	kg DM/cow/month
May	26	806	4.5	139.5
June	24	720	5.9	177.0
July	19.9	617	8.6	266.6
August	28.8	868	9.7	300.7

Total grass eaten per hectare per fortnight or per month will be equal kg DM/cow/fortnight or month times the stocking rate, in this case 3.25 cows/ha.

Grass surplus or deficit per fortnight or per month will equal the difference between total grass grown/ha and total grass eaten.

Fortnightly Surpluses and Deficits

Month and Day	Grass Grown kg DM	Grass Eaten kg DM	Surplus or Deficit kg DM
May 1 - 14	364	204.75	+ 159.25
May 15 - 29	364	204.75	+ 159.25
May 30 - June 12	340	359.35	+ 80.65
June 13 - 27	336	268.45	+ 67.55
June 28 - July 12	286.8	373.75	- 86.95
July 13 - July 27	278.6	391.3	- 112.7
July 28 - Aug 1	367.7	430.63	- 62.9
Aug 12 - Aug 26	392.0	441.35	- 49.35

If average cover on farm is 1120 kg DM/ha, and the cows graze paddocks to leave behind a cover of 1000 kg DM/ha, and the desired cover is 1700 kg DM/ha ($\simeq$ 1500 lb/acre), when cows calve; then the paddocks to be grazed should have an average cover of 2400 kg DM/ha

i.e. $\frac{1000 + x}{2} = 1700; \quad x = (3400 - 1000) = 2400$ kg DM/ha.

To save this pasture supplementary feed has to be used, e.g. hay.

Estimated feed budget without supplemental hay

Date and cover at the start kg DM/ha	Requirement per ha kg DM/ha	Grass grown kg DM/ha	Total Grass grown kg DM/ha	Total DM Eaten	Cover at the end of day
29.4.75 1120	14.63	312 (12 days)	1432	175.5	10.5.75 1256.5
11.5.75 1256.5	14.63	364	1620.5	204.8	24.5.75 1415.7
25.5.75 1415.7	14.63/19.2	350	1765.7	236.8	7.6.75 1528.9
8.6.75 1528.9	19.2	336	1864.9	268.8	21.6.75 1596.1
22.6.75 1596.1	19.2/27.95	315.5	1911.6	312.55	5.7.75 1599.05
6.7.75 1599.05	27.95	278.6	1877.65	391.3	19.7.75 1486.35
20.7.75 1486.35	27.95/31.53	302.9	1789.25	402.04	2.8.75 1387.2
3.8.75 1387.2	31.53	392.0	1779.21	441.4	16.8.75 1337.8
17.8.75 1337.8	31.53	392	1729.81	441.4	30.8.75 1288.4

Desired cover is 1700 kg DM/ha. Without supplementary hay the cover is 1288.4 kg DM/ha. The shortage is thus 411.59 kg DM/ha. This shortage has to be covered using the supplemental hay. Hay bale is assumed to weigh 22.7 kg DM. It is also assumed to have 70% grass equivalence:

$$\text{Thus} \quad 411.59 \times \frac{100}{70} = 587.985 \text{ kg hay/ha}$$

This is equal to 25.9 bales/ha

$\simeq$ 26 bales/ha

This will equal 337.0 bales for the whole farm.

Estimated feed budget with supplemental hay

If 15 bales are fed in May, 9 in June and 2 in July, the new cover is expected to be as follows:

Date and cover to start kg DM/ha	Requirement per ha kg DM/ha	Grass Grown kg/ha	Total grass grown kg/ha	Total Dry Matter Consumed for 14 days kg DM/ha	DM fed as hay kg DM	DM of grass grazed kg DM/ha	Cover at end of day kg DM/ha
29.4.75 / 1120	14.63	312 (12 days)	1432	175.5	127.12	48.38	10.5.75 / 1383.6
11.5.75 / 1383.6	14.63	364	1747.6	208.00	111.23	93.57	24.5.75 / 1654.05
25.5.75 / 1654.05	14.63/19.2	350	2004.05	236.8	79.45	157.35	7.6.75 / 1846.7
8.6.75 / 1846.7	19.2	336	2182.7	268.8	63.56	205.24	21.6.75 / 1977.46
22.6.75 / 1977.46	19.2/27.2	315.5	2292.96	312.55	31.78	280.77	5.7.75 / 2012.19
6.7.75 / 2012.19	27.2	278.6	2290.79	391.3	-	391.3	19.7.75 / 1899.49
20.7.75 / 1899.49	27.2/31.53	302.9	2202.39	402.04	-	402.04	2.8.75 / 1860.35
3.8.75 / 1860.35	31.53	392	2192.35	441.4	-	441.4	16.8.75 / 1750.95
17.8.75 / 1750.95	31.53	392	2142.95	441.4	-	441.4	30.8.75 / 1701.55

Target of 1700 kg DM/ha is attained.

Estimated budget for Farmlet B (On-group)

This follows the same pattern of calculations. The growth rates were taken as follows:

May	26 kg DM/ha/day
June	23 kg DM/ha/day
July	19 kg DM/ha/day
August	26 kg DM/ha/day

1. Cows requirements - same as in A Group.
2. Cover to start with - 1120 kg DM/ha.
3. No. of cows, 42; area 12.95 ha and stocking rate = 3.25 cows/ha.

The budget was worked out as in Farmlet A, i.e. with no hay and with hay, thus:

Estimated feed budget without hay

Date and cover at the start kg DM/ha	Requirement per ha kg DM/ha	Grass grown kg DM/ha	Total Grass grown kg DM/ha	Total Dm Eaten for 14 days	Cover at the end of day
29.4.75 / 1120	14.63	312 (12 days)	1432	175.5	10.5.75 / 1256.5
11.5.75 / 1256.5	14.63	364	1620.5	204.8	24.5.75 / 1415.7
25.5.75 / 1415.7	14.63/19.2	343	1758.5	236.8	7.6.75 / 1521.7
8.6.75 / 1521.7	19.2	322	1843.7	268.8	21.6.75 / 1574.9
22.6.75 / 1574.9	19.2/27.95	302	1876.9	312.55	5.7.75 / 1564.35
6.7.75 / 1564.35	27.95	266	1830.35	391.3	19.7.75 / 1439.05
20.7.75 / 1439.05	27.95/31.53	284	1723.05	402.04	2.8.75 / 1321.01
3.8.75 / 1321.01	31.53	364	1685.01	441.4	16.8.75 / 1243.61
17.8.75 / 1243.61	31.53	364	1607.61	441.4	30.8.75 / 1166.2

If cows leave behind 500 kg DM/ha, and the aim is to have a cover of 1700 kg DM/ha when cows calve, cows have to graze paddocks with

$$\left(\frac{x + 500}{2} = 1700\right) \quad = \quad 2900 \text{ kg DM/ha}$$

$$x = \underline{2900}$$

Without hay, cover is 1166 kg DM/ha; shortfall is 534 kg DM/ha.

Hay is assumed to have 70% grass equivalence and about 22.7 kg of hay is equivalent to one bale.

$\therefore$ $534 \times \frac{100}{70}$ = 763 kg DM of hay/ha

This is equal to 33.6 bales/ha = 34 bales/ha.

For 12.95 ha 440 bales are required.

Estimated budget with supplemental hay

If 20 bales are fed in may, 10 in June and 4 in July, the new cover is expected to be as follows:

Date and cover to start kg DM/ha	Requirement per ha kg DM/ha	Grass Grown kg/ha	Total Grass grown kg/ha	Total Dry Matter Consumed for 14 days kg DM/ha	DM fed as hay kg DM	DM of grass grazed kg DM/ha	Cover at end of day kg DM/ha
29.4.75 1120	14.63	312 (12 days)	1432	175.5	158.9	16.6	10.5.75 1415.4
11.5.75 1415.4	14.63	364	1779.4	204.8	158.9	45.9	24.5.75 1733.5
25.5.75 1733.5	14.63/19.2	343	2076.5	236.8	79.45	157.35	7.6.75 1919.15
8.6.75 1919.15	19.2	322	2241.15	268.8	79.45	189.35	21.6.75 2051.8
22.6.75 2051.8	19.2/27.95	302	2353.8	312.55	31.78	280.77	5.7.75 2073.03
6.7.75 2073.03	27.95	266	2339.03	391.3	31.78	359.52	19.7.75 1979.51
20.7.75 1979.51	27.95/31.53	284	2263.51	402.04	-	402.04	2.8.75 1861.47
3.8.75 1861.47	31.53	364	2225.47	441.4	-	441.4	16.8.75 1784.07
17.8.75 1784.07	31.53	364	2148.07	441.4	-	441.4	30.8.75 1706.67

Target of 1700 kg DM/ha is achieved.

APPENDIX III: Dry matter determination from each paddock using the Massey Grass Meter (April)

Cover as at 29th April 1975

On/Off System

Paddock No.	Mean Meter Reading (15 Samples)	Calculated Yields (kg DM/ha)	
		Linear Regression	Curvilinear Graphs
1	83.3	1010	1025
5	84.3	907	800
9	80.4	1306	1420
12	83.3	1010	1025
15	84.3	907	800
16	83.1	1030	1075
21	79.6	1388	1520
22	81.2	1224	1310
23	82.2	1122	1200
26a	80.8	1265	1370
b	81.0	1245	1340
30	79.9	1357	1470
31	81.5	1194	1275
33	82.0	1143	1225
38	84.5	887	775
40	82.6	1081	1125
42	82.0	1143	1225
	1396	19218	19980
	82.12	1130.5	1175.3

APPENDIX III: continued (April)

On System

Paddock No.	Mean Meter Reading (15 Samples)	Calculated Yields (kg DM/ha)	
		Linear Regression	Curvilinear Graphs
8	79.8	1368	1475
11	84.0	940	950
13	84.0	940	950
14	83.5	989	1000
17	80.3	1316	1425
24	83.3	1010	1025
27a	81.5	1194	1275
b	81.3	1214	1300
28a	84.0	940	950
b	83.7	969	960
c	83.3	1010	1025
32	82.3	1112	1175
34	82.0	1143	1225
37	80.6	1286	1375
39	80.9	1255	1360
41	81.5	1194	1275
49a	79.5	1398	1525
	1395.5	19278	20270
	82.09	1134	1192.4

APPENDIX III: continued (May)

On/Off System

Paddock No.	Mean Meter Reading (15 Samples)	Calculated Yields (kg DM/ha)	
		Linear Regression	Curvilinear Graphs
1	78.50	1597	1630
5	80.9	1375	1360
9	74.2	2011	2025
12	79.5	1513	1525
15	80.6	1407	1320
16	78.0	1647	1675
21	78.4	1614	1640
22	74.5	1986	2000
23	81.1	1343	1310
26a	81.3	1343	1300
b	81.7	1300	1250
30	79.0	1558	1575
31	80.5	1413	1420
33	80.9	1375	1360
38	80.6	1407	1390
40	81.4	1331	1290
42	81.9	1287	1230
	1353	25507	25300
	79.59	1500	1488

APPENDIX III: continued (May)

On System

Paddock No.	Mean Meter Reading (15 Samples)	Calculated Yields (kg DM/ha)	
		Linear Regression	Curvilinear Graphs
8	72.3	2183	2175
11	79.3	1527	1550
13	78.7	1589	1600
14	83.0	1174	1075
17	74.4	1992	2025
24	78.3	1627	1680
27a	76.7	1772	1800
b	78.3	1627	1680
28a	79.0	1558	1575
b	79.9	1476	1470
c	79.0	1558	1575
32	80.3	1438	1425
34	77.7	1683	1710
37	77.0	1747	1775
39	83.5	1130	1000
41	77.5	1699	1730
49a	81.9	1281	1230
	1336.8	27066	27075
	78.6	1592	1593

APPENDIX III: continued (June)

On/Off System

Paddock No.	Mean Meter Reading (15 Samples)	Calculated Yields (kg DM/ha)	
		Linear Regression	Curvilinear Graph
1	75.7	1709	1775
5	76.2	1651	1725
9	78.5	1406	1490
12	77.7	1493	1590
15	77.3	1528	1610
16	80.9	1146	1200
21	73.2	1976	1925
22	75.6	1715	1790
23	75.1	1767	1825
26a	77.5	1507	1600
b	76.2	1651	1725
30	77.0	1564	1650
31	73.4	1954	1900
33	75.1	1767	1825
38	81.0	1131	1200
40	76.7	1601	1625
42	75.9	1680	1750
	1303	27247	28255
	76.6	1603	1660

APPENDIX III: continued (June)

On System

Paddock No.	Mean Meter Reading (15 Samples)	Calculated Yield (kg DM/ha)	
		Linear Regression	Curvilinear Graph
8	69.4	2416	2175
11	70.9	2230	2050
13	70.9	2222	2050
14	75.5	1731	1775
17	64.0	2973	2800
24	85.3	661	650
27a	69.8	2345	2125
b	70.3	2290	2075
28a	68.0	2533	2300
b	69.8	2345	2125
c	71.9	2120	1975
32	82.9	929	975
34	82.9	921	975
37	67.6	2583	2350
39	79.7	1268	1325
41	82.4	979	1025
49a	76.3	1637	1725
	1257.7	32183	30475
	73.98	1893	1793

APPENDIX III; continued (July)

On/Off System

Paddock No.	Mean Meter Reading (15 samples)	Calculated Yield (kg DM/ha)	
		Linear Regression	Curvilinear Graph
1	75.33	1797	1725
5	76.06	1700	1675
9	77.0	1574	1600
12	77.6	1486	1425
15	76.27	1672	1660
16	78.06	1433	1475
21	76.86	1593	1610
22	75.06	1833	1775
23	73.93	1984	1920
26a	77.46	1530	1550
b	76.06	1700	1680
30	76.06	1700	1680
31	79.93	1183	1275
33	77.66	1486	1425
38	78.93	1317	1400
40	80.33	1130	1225
42	75.86	1726	1700
	1308.49	26825	26800
	76.97	1578	1576

APPENDIX III: continued (July)

On System

Paddock No.	Mean Meter Reading (15 Samples)	Calculated Yield (kg DM/ha)	
		Linear Regression	Curvilinear Graph
8	84.3	625	550
11	70.7	2415	2300
13	68.2	2745	2850
14	72.0	2244	2150
17	62.7	3467	3600
24	81.7	968	1050
27a	85.3	493	350
b	85.5	458	300
28a	67.2	2877	3050
b	67.5	2834	2975
c	68.4	2719	2800
32	82.2	897	930
34	81.3	1012	1075
37	64.7	3213	3475
39	78.4	1399	1450
41	82.2	897	930
49a	76.0	1708	1700
	1278.4	30970	31535
	75.2	1822	1855

APPENDIX IV: Regrowth on Grazed Paddocks (On/off)

Paddock No.	Date cut after grazing and the amount of DM ha kg DM/ha	Regrowth for approx. 21 days kg DM/ha	Regrowth for approx. 42 days kg DM/ha	Regrowth for approx. 63 days kg DM/ha
21	2.5.75 986	(21)* 23.5.75 1290 - 986 = 304 kg = 14.5 kg DM/ha/day	(21) 13.6.75 1663 - 1290 = 373 kg = 17.76 kg DM/ha/day	
31	5.5.75 1042	(20) 25.5.75 1284 - 1042 = 222 kg = 11.1 kg DM/ha/day	(23) 17.6.75 1696 - 1264 = 432 kg = 18.78 kg DM/ha/day	
40	8.5.75 867	(21) 29.5.75 1115 - 867 = 248 kg = 11.8 kg DM/ha/day	(21) 19.6.75 1561.3 - 1115 = 446.3 kg = 21.25 kg DM/ha/day	
33	11.5.75 1075	(22) 2.6.75 1415 - 1075 = 340 kg = 15.45 kg DM/ha/day	(21) 23.6.75 1674.4 - 1415 = 259.4 kg = 12.35 kg DM/ha/day	
23	17.5.75 829	(24) 10.6.75 1190 - 829 = 361 kg = 15.04 kg DM/ha/day	(19) 29.6.76 1483 - 1190 = 293 kg = 15.42 kg DM/ha/day	
26 a & b	21.5.75 962	(23) 13.6.75 1375.4 - 962 = 413.4 kg = 17.97 kg DM/ha/day	(24) 7.7.75 1734 - 1375.4 = 358.6 kg = 14.94 kg DM/ha/day	

*( ) days of regrowth

APPENDIX IV: continued

Paddock No.	Date cut after grazing and the amount of DM ha kg DM/ha	Regrowth for approx. 21 days kg DM/ha	Regrowth for approx. 42 days kg DM/ha	Regrowth for approx. 63 days kg DM/ha
30	26.5.75 1036	(21) 16.6.75 1347.4 - 1036 = 311.4 kg = 14.83 kg DM/ha/day	(22) 7.7.75 1696 - 1347.4 = 348.6 kg = 15.85 kg DM/ha/day	
22	30.5.75 1023	(21) 20.6.75 1434 - 1023 = 411 kg = 19.6 kg DM/ha/day	(21) 11.7.75 1749 - 1434 = 315 kg = 15.0 kg DM/ha/day	(17) 28.7.75 2122 - 1749 = 373 kg = 21.93 kg DM/ha/day
1	1.6.75 1021.3	(21) 22.6.75 1277 - 1021.3 = 255.7 kg = 12.2 kg DM/ha/day	(21) 13.7.75 1497.4-1277.3 = 220.1 kg = 10.48 kg DM/ha/day	(25) 7.8.75 2182.4-1497.4 = 685 kg = 27.4 kg DM/ha/day
5	3.6.75 909.4	(20) 23.6.75 1327.1-909.4 = 417.7 kg = 20.9 kg DM/ha/day	(21) 14.7.75 1609.1-1327.1 = 282 kg = 13.42 kg DM/ha/day	(18) 1.8.75 2171.2-1609.1 = 562.1 kg = 31.2 kg DM/ha/day
9	7.6.75 1017.2	(21) 28.6.75 1212.3-1017.2 = 195.1 kg = 9.3 kg DM/ha/day	(21) 19.7.75 1411.2-1212.3 = 198.9 kg = 9.5 kg DM/ha/day	(12) 31.7.75 1731.4-1411.2 = 320.2 kg = 26.7 kg DM/ha/day
12	11.6.75 1035.3	(21) 2.7.75 1354.1-1035.3 = 318.8 kg = 15.18 kg DM/ha/day	(21) 23.7.75 1617.5-1354.1 = 263.4 kg = 12.5 kg DM/ha/day	(10) 2.8.75 1980.2-1617.5 = 362.7 kg = 36.2 kg DM/ha/day

APPENDIX IV: continued

Paddock No.	Date cut after grazing and the amount of DM/ha kg DM/ha	Regrowth for approx. 21 days kg DM/ha	Regrowth for approx. 42 days kg DM/ha	Regrowth for approx. 63 days kg DM/ha
16	19.6.75 980	(21) 10.7.75 1273.6 - 980 = 243.6 kg = 11.6 kg DM/ha/day	(21) 31.7.75 1482.2-1223.6 = 258.6 kg = 12.3 kg DM/ha/day	
38	21.6.75 950	(21) 12.7.75 1216.3 - 950 = 266.3 kg = 12.7 kg DM/ha/day	(9) 21.7.75 1328.84-1216.3 = 112.5 kg = 12.5 kg DM/ha/day	
2nd Rotation 21	24.6.75 1033	(21) 15.7.75 1316.1-1033 = 283.1 kg = 13.5 kg DM/ha/day	(21) 5.8.75 1868.5-1316.1 = 552.4 kg = 26.3 kg DM/ha/day	
31	28.6.75 959	(21) 19.7.75 1406.4 - 959 = 447.4 kg = 21.3 kg DM/ha/day	(9) 28.7.75 1561.3-1406.4 = 154.9 kg = 17.2 kg DM/ha/day	
40	2.7.75 1007	(20) 22.7.75 1268.5-1007 = 261.5 kg = 12.45 kg DM/ha/day		
33	6.7.75 1000.2	(20) 26.7.75 1466.3-1000.2 = 466.1 kg = 23.3 kg DM/ha/day		

APPENDIX IV: continued

Paddock No.	Date cut after grazing and the amount of DM/ha kg DM/ha	Regrowth for approx. 21 days kg DM/ha	Regrowth for approx.42 days kg DM/ha	Regrowth for approx.63 days kg DM/ha
42	9.7.75 984.5	(15) 24.7.75 1303.5-984.5 = 319 kg = 21.3 kg DM/ha/day		
23	13.7.75 806.4	(21) 4.8.75 1308.2-806.4 = 501.8 kg = 23.9 kg DM/ha/day		
26a	16.7.75 931	(21) 6.8.75 1286.4-931 = 355.4 kg = 16.9 kg DM/ha/day	(9) 15.8.75 1613.7-1286.4 = 327.3 kg = 36.4 kg DM/ha/day	

APPENDIX IV: continued

Grass Growth Rates for the (On-Group) On-System

Paddock No.	Date cut after grazing and the amount of DM/ha kg DM/ha	Regrowth for approx. 21 days kg DM/ha	Regrowth for approx. 42 days kg DM/ha	Regrowth for approx. 63 days kg DM/ha
49a	5.5.75 588	(23)* 28.5.75 943 - 588 = 355 kg = 15.43 kg DM/ha/day	(21) 18.6.75 1417.3 - 943 = 474.3 kg = 22.6 kg DM/ha/day	(21) 9.7.75 1827.3-1417.3 = 410 kg = 19.5 kg DM/ha/day
39	15.5.75 534.2	(24) 9.6.75 795.2-534.2 = 261 kg = 10.9 kg DM/ha/day	(21) 30.6.75 1263.5-795.2 = 468.3 kg = 22.3 kg DM/ha/day	(21) 21.7.75 1605.5-1263.5 = 342 kg = 16.3 kg DM/ha/day
32	25.5.75 504	(25) 19.6.75 606.4 - 504 = 102.4 kg = 4.1 kg DM/ha/day	(21) 10.7.75 730.7-606.4 = 124.3 kg = 5.92 kg DM/ha/day	(17) 23.7.75 1113.8-730.7 = 383.1 kg = 22.5 kg DM/ha/day
41	3.6.75 560	(23) 26.6.75 805 - 560 = 245 kg = 10.7 kg DM/ha/day	(21) 17.7.75 983.4 - 805 = 178.4 kg = 8.5 kg DM/ha/day	(6) 23.7.75 1103.8-983.4 = 120.4 kg = 20.1 kg DM/ha/day
34	10.6.75 520.6	(23) 3.7.75 785.2-520.6 = 264.6 kg = 11.5 kg DM/ha/day	(21) 24.7.75 1089.1-785.2 = 303.9 kg = 14.5 kg DM/ha/day	

*( ) days of growth

APPENDIX IV; continued

Paddock No.	Date cut after grazing and the amount of DM/ha kg DM/ha	Regrowth for approx. 21 days kg DM/ha	Regrowth for approx. 42 days kg DM/ha	Regrowth for approx. 63 days kg DM/ha
24	17.6.75 479	(23) 10.7.75 816.8 - 479 = 337.8 kg = 14.7 kg DM/ha/day	(15) 25.7.75 1079.9-816.8 = 263.1 kg = 17.54 kg DM/ha/day	
8	23.6.75 431.2	(37) 31.7.75 809.1-431.2 = 377.9 kg = 10.2 kg DM/ha/day		
27 a & b	3.7.75 543.1	(26) 29.7.75 709.3 -543.1 = 166.2 kg = 6.4 kg DM/ha/day	(17) 15.8.75 1270-709.3 = 561.4 kg = 33.0 kg DM/ha/day	
28 a & b	12.7.75 791.3	(19) 31.7.75 1177.2-791.3 = 385.9 kg = 20.3 kg DM/ha/day	(13) 13.8.75 1466.4-1177.2 = 289.2 kg = 22.25 kg DM/ha/day	
28c	17.7.75 528.6	(23) 9.8.75 799 - 528.6 = 270.6 kg = 11.8 kg DM/ha/day	(9) 18.8.75 1024.7-799 = 225.7 kg = 25.0 kg DM/ha/day	
11 Ungrazed during the trial	27.4.75 784	(48) 12.6.75 1865 - 784 = 1081 kg = 24.0 kg DM/ha/day	(27) 8.7.75 2344.7-1865 = 479.7 kg = 17.77 kg DM/ha/day	(18) 26.7.75 2566 - 2345 = 221 kg = 12.3 kg DM/ha/day

APPENDIX IV: continued

Paddock No.	Date cut after grazing and the amount of DM/ha kg DM/ha	Regrowth for approx. 21 days kg DM/ha	Regrowth for approx. 42 days kg DM/ha	Regrowth for approx. 63 days kg DM/ha
17	25.4.75	(48) 12.6.75	(26) 8.7.75	(21) 29.7.75
Ungrazed during the trial	1008	2159.1-1008 = 1151.1 kg = 23.98 kg DM/ha/day	2611.4-2159.1 = 452.3 kg = 17.4 kg DM/ha/day	2796--2611.4 = 184.6 kg = 8..79 kg DM/ha/day

13)
14) Not grazed during the trial
37)

APPENDIX V: Estimation of DM consumed/cow/day on paddock basis

On/Off System

Paddock No. & area	DM in a Paddock before grazing	DM left after grazing per paddock	kg DM consumed per paddock	Hay consumed per paddock (bales)	Hay/cow per day (kg DM)	Hay grass equivalent (70%)	No. of breaks	Area grazed per day ha	Amount grass consumed per cow per day	Total DM consumed per day
1st Rotation										
21 0.92 ha (2.27 ac)	1339.5	906.75	432.72	6	1.08*	0.76	3	0.307	3.435	4.2 (4.515)
31 0.94 ha (2.32 ac)	1185.5	980.14	206.4	9	1.62	1.134	3	0.313	1.63	2.76 (3.25)
40 0.749 ha (1.85 ac)	1062.0	649.4	413.4	9	1.62	1.134	3	0.2496	3.28	4.41 (4.9)
33 0.834 ha (2.06 ac)	1307.7	896.7	411	6	1.08	0.76	3	0.278	3.262	4.02 (4.342)
42 0.7449 ha (1.84 ac)	1047.7	571.5	476.2	9	1.62	1.134	3	0.2483	3.8	4.93 (5.42)
23 0.8543 ha (2.11 ac)	1119.5	791.4	328.1	12	2.16	1.512	3	0.28476	2.6	4.11 (4.76)
26 a & b 1.004 ha	1491.94	965.85	526.1	15	2.27	1.59	4	0.251	3.13	4.72 (5.40)

APPENDIX V: continued

Paddock No. & area	DM in a Paddock before grazing	DM left after grazing per paddock	kg DM consumed per paddock	Hay consumed per paddock (bales)	Hay/cow per day (kg DM)	Hay grass equiv-alent (70%)	No. of breaks	Area grazed per day ha	Amount grass consumed per cow per day	Total DM consumed per day
30 0.9595 ha (2.37ac)	1695.72	994.04	701.68	20	2.16	1.52	5	0.1919	3.34	4.85 (5.5)
22 0.7976 ha (1.97 ac)	1458	815.94	642.1	20	2.7	1.89	4	0.1994	3.82	5.71 (6.52)
1 0.583 ha (1.44 ac)	848.26	595.24	253.02	8	2.16	1.512	2	0.2915	3.01	4.52 (5.17)
5 0.7328 ha (1.81 ac)	880.09	666.11	213.98	4	2.16	1.512	1	0.7328	5.09	6.60 (7.25)
9 0.8097 ha (2 ac)	1571.63	823.46	748.17	20	2.16	1.512	5	0.16194	3.56	5.07 (5.72)
12 0.8947 ha (2.21 ac)	1576.5	892.91	683.59	16	2.16	1.512	4	0.22367	4.069	5.6 (6.231)
15 0.94 ha (2.32 ac)	1609.3	925.9	683.4	16	2.162	1.513	4	0.235	4.069	5.59 (6.23)
16 0.6802 ha (1.65 ac)	1350.9	666.6	684.3	16	3.162	1.512	4	0.17005	4.073	5.6 (6.235)

APPENDIX V: continued

Paddock No. & area	DM in a Paddock before grazing	DM left after grazing per paddock	kg DM consumed per paddock	Hay consumed per paddock (bales)	Hay/cow per day (kg DM)	Hay grass equiv-alent (70%)	No. of breaks	Area grazed per day ha	Amount grass consumed per cow per day	Total DM consumed per day
38 0.5668 ha (1.4 ac)	890.4	538.5	351.9	8	2.162	1.512	2	0.2834	4.19	5.7 (6.352)
2nd Rotation										
21 0.93 ha	1563.72	950.4	513.32	12	2.162	1.512	3	0.306	4.87	6.40 (7.032)
31 0.94 ha	1676.02	901.5	774.5	22	2.973	2.08	4	0.235	4.61	6.70 (7.583)
40 0.74 ha	1068.82	745.2	310.8	28	3.73	2.65	4	01.850	1.85	4.50 (5.633)
33 0.834 ha	1426.3	834.2	592.1	28	3.783	2.65	4	0.2085	3.524	6.20 (7.307)
42 40 cows 0.745 ha	1105.6	733.5	372.1	21	3.97	2.80	3	0.248	3.70	6.50 (7.67)
23 40 cows 0.8543 ha	1457.3	688.9	768.4	28	3.783	2.65	4	0.2133	4.8	7.45 (8.583)

APPENDIX V: continued

Paddock No. & area	DM in a paddock before grazing	DM left after grazing per paddock	kg DM consumed per paddock	Hay consumed per paddock (bales)	Hay/cow per day (kg DM)	Hay grass equiv-alent (70%)	No. of breaks	Area grazed per day ha	Amount grass consumed per cow per day	Total DM consumed per day
26a	929.4	467.4	462	10	3.43	2.34	2	0.201	6.79	9.13 (10.573)

Average weight of 1 bale = 22.7 kg

( ) Hay kg DM/cow/day + grass kg DM/day

Unbracketed figures are all equivalent to grass (Hay grass equivalence = 70%)

APPENDIX V: continued

On System

Paddock No. & area	DM in a paddock before grazing	DM left after grazing per paddock	kg DM consumed per paddock	Hay consumed per paddock (bales)	Hay/cow per day (kg DM)	Hay grass equiv-alent (70%)	No. of breaks	Area grazed per day ha	Amount grass consumed per cow per day	Total DM consumed per day
49a 0.8907 ha (2.2 ac)	1373.2	523.91	849.29	80	4.32	3.024	10	0.089	2.02	5.044 (6.34)
39 0.88 ha (2.16 ac)	1359.23	467	892.23	64	3.84	2.688	9	0.10	2.36	5.048 (6.20)
32 0.93 ha (2.29 ac)	1487.4	468.72	10018.18	60	3.242	2.268	10	0.093	2.425	4.693 (5.667)
41 0.72 ha (1.78 ac)	1120.03	403.8	716.3	42	3.24	2.268	7	0.103	2.44	4.71 (5.68)
24 0.895 ha (2.21 ac)	1784.3	429	1355.3	35	2.70	1.89	7	0.128	4.61	6.5 (7.31)
8 0.761 ha (1.88 ac)	2060.5	328.1	1732.3	24	1.62	1.135	8	0.095	5.15	6.285 (6.77)
27 a & b 1.445 ha (2.58 ac)	2263.6	567.4	1696.2	27	1.621	1.135	9	0.11605	4.49	5.62 (6.11)

APPENDIX V: continued

Paddock No. & area	DM in a paddock before grazing	DM left after grazing per paddock	kg DM consumed per paddock	Hay consumed per paddock (bales)	Hay/cow per day (kg DM)	Hay grass equiv-alent (70%)	No. of breaks	Area grazed per day ha	Amount grass consumed per cow per day	Total DM consumed per day
28a & b 38 cows 1.16 ha (2.86 ac)	2881.6	917.9	1963.7	16	1.19	0.833	8	0.145	6.46	7.29 (7.65)
28c 34 cows 0.6802 ha (1.68 ac)	1545.0	359.6	1185.4	10	1.34	0.6802	5	0.13604	6.973	7.91 (8.313)

( ) Hay kg DM/cow/day + grass kg DM/day

Unbracketed figures are all equivalent to grass (hay grass equivalence = 70%).

APPENDIX VI: Metereological Data as recorded by Massey University, Palmerston North 1971-75 (recorded at 8.30 a.m.)

1971

Month	Total Rainfall mm	Mean Soil Temperature (10 cm) °C	Mean Grass Minimum temperature °C	Mean Air Temperature °C
January	18.50	19	12.7*	18.6
February	132.10	19.5	12.7*	19.5
March	134.60	15.8	8.3*	16.7
April	90.40	13.3	7.3*	14.9
May	33.8	10.9	5.2*	12.4
June	110.5	10.1	4.7	11.5
July	47.8	6.7	1.2	8.45
August	116.5	9.0	4.0	10.5
September	80.2	9.9	4.4	10.9
October	123.0	12.1	6.2	12.35
November	59.6	15.4	6.7	14.5
December	54.4	18.1	9.3	17.0
1972				
January	60.1	18.2	10.8	17.1
February	46.8	17.0	9.0	16.45
March	135.1	16.9	11.0	17.3
April	70.2	13.2	6.2	13.6
May	110.9	9.5	2.9	10.4
June	39.4	5.3	- 1.3	6.7
July	101.4	6.9	1.4	8.9
August	77.7	6.3	- 2.8	7.8
September	55.0	10.2	4.8	11.3
October	64.8	12.9	6.7	15.9
November	29.6	16.5	9.1	15.6
December	39.8	16.2	8.6	14.7

* From D.S.I.R. Data - Massey started compiling the data in June 1971.

APPENDIX VI: continued

Month	Total Rainfall mm	Mean Soil Temperature (10 cm) °C	Mean Grass Minimum Temperature °C	Mean Air Temperature °C
1973				
January	5.13	18.9	10.2	17.6
February	15.0	18.3	10.2	18.0
March	100.4	16.6	10.1	16.9
April	57.4	13.4	7.2	14.0
May	120.0	11.4	6.8	11.9
June	81.0	8.2	2.3	9.0
July	29.8	6.4	0.8	8.0
August	62.0	8.2	2.2	9.5
September	152.5	10.6	5	11.8
October	33.3	13.0	5.5	12.7
November	59.4	15.6	8.7	15.0
December	59.4	18.8	9.7	17.3
1974				
January	30.7	18.6	9.2	17.1
February	55.5	20.3	13.9	20.4
March	20.6	14.9	6.3	14.7
April	110.0	13.7	7.9	14.8
May	120.8	11.4	4.8	11.7
June	39.6	7.6	1.9	8.9
July	251.2	8.1	- 5.5	9.2
August	82.1	7.7	1.6	8.6
September	116.2	10.6	5.5	11.9
October	127.5	12.7	5.9	12.5
November	53.1	15.5	7.9	15.6
December	77.9	18.8	9.9	17.7

APPENDIX VI: continued

Month	Total Rainfall mm	Mean Soil Temperature (10 cm) °C	Mean Grass Minimum Temperature °C	Mean Air Temperature °C
1975				
January	37.7	20.3	12.1	20.00
February	29.6	19.1	12.3	19.3
March	53.2	17.0	11.1	17.9
April	71.4	13.3	7.7	14.6
May	129.5	11.0	6.3	12.0
June	66.9	6.7	0.7	8.1
July	128.3	6.1	0.8	7.7
August	161.0	7.7	3.3	9.7
September	55.6	9.6	4.2	10.6
October	83.1	12.6	7.2	13.3
November	54.2	13.3	7.0	13.0
December	101.7	15.7	8.8	14.9

APPENDIX VII: Dry Matter Estimation by cutting and visual appraisal

The Cutting and the Visual Assessment Techniques

On/Off System

Paddock No.	Cutting Technique		Visual or Eye Technique	
	DM present before grazing kg DM/ha	DM present after grazing kg DM/ha	DM present before grazing kg DM/ha	DM present after grazing kg DM/ha
1st Rotation				
21	1456	986	1400	1000
31	1264	1042.7	1200	900
40	1418	867	1250	900
33	1568	1075.2	1350	1100
42	1405.6	767.2	1350	700
23	1310.4	829.3	1200	700
26 a & b	1486	962	1350	1100
30	1767.28	1036	1500	1100
22	1827.84	1022.9	1700	1000
1	1454.88	1021.3	1350	1050
5	1200.6	909.4	1000	850
9	1940.96	1017	2000	900
12	1762.	997	1450	900
15	1712.5	985.4	1450	950
16	1985.8	980	1800	900
38	1571.4	950	1450	900
	15131.26	15448.4	22800	14950
	1570.70	965.5	1425	934.4

APPENDIX VII: continued

On System

Paddock No.	Cutting Technique		Visual or Eye Technique	
	DM present before grazing kg DM/ha	DM present after grazing kg DM/ha	DM present before grazing kg DM/ha	DM present after grazing kg DM/ha
44a	1541.2	588	1400	500
39	1544.6	534.2	1450	500
32	1598.24	504	1450	300
41	1553.4	560	1500	500
34	1786.4	521	1800	550
24	1994	479	2100	300
8	2707.6	531.2	2800	400
27 a & b	2167.2	543.2	2000	550
28 a & b	2484.2	791.3	2500	800
28c	2271.4	527	2200	500
	19647.94	5278.9	19200	4900
	1965	548	1920	490

APPENDIX VII; continued

Average dry matter available per hectare obtained by the cutting and visual techniques

A. Cutting Technique

On/Off System			On System		
Mean dry matter of 16 paddocks kg DM/ha	Range	S.E.M.	Mean dry matter of 10 paddocks kg DM/ha	Range	S.E.M.
Before Grazing					
1570.7	1200-1985.8	59.6	1965	1544-2707.6	135.35
After Grazing					
965.5	829.3-1075	20.9	548	431-791	30.3

B. Visual Assessment Technique

On/Off System			On System		
Before Grazing					
1425	1000-2000	60.6	1920	1400-2800	153.87
After Grazing					
934.4	700-1100	30.86	490	300-800	45.22

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