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**THE EFFECT OF OESTRADIOL-17 $\beta$  (COMPUDOSE®) ON  
LIVEWEIGHT GAIN, HERBAGE INTAKE AND CIRCULATING  
HORMONE CONCENTRATIONS IN STEERS AT PASTURE**

**A thesis presented in partial fulfilment  
of the requirements for the degree  
of  
Master of Agricultural Science in Animal Science  
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New Zealand**

**GILBERTO ARANDA OSORIO**

**1995**

**To my family**

For their immense support and encouragement throughout my life.

**To Universidad Automoma Chapingo**

For giving me the opportunity to learn about agricultural sciences.

**To Mexico**

For teaching me how important and wonderful life is.

# THE EFFECT OF OESTRADIOL-17 $\beta$ (COMPUDOSE®) ON LIVELWEIGHT GAIN, HERBAGE INTAKE AND CIRCULATING HORMONE CONCENTRATIONS IN STEERS AT PASTURE

## ABSTRACT

World food production needs to increase as world population is increasing. One method of achieving this is to improve the efficiency of food production. Efficient meat production in steers is affected by growth rate, mature weight and composition of the growth. It is possible to manipulate growth rate by the administration of sex steroids. Compudose® (oestradiol-17 $\beta$ ) improves liveweight gain (14-17%) and feed conversion efficiency (10-12%) in beef cattle under feedlot and grazing conditions. There is little information available on feed intake and hence efficiency of liveweight gain under New Zealand pastoral systems. Therefore, this study was designed to evaluate over a 203 day period the effect of Compudose® on liveweight gain, herbage intake, grazing behaviour and circulating hormone and metabolite concentrations in steers grazing ryegrass-white clover pastures. Twenty 14-month-old Friesian steers and sixteen 14-month-old Angus cross were randomly assigned within breed to either Compudose® or no-Compudose®. Herbage intake and grazing behaviour were measured on two occasions (days 34-50 and days 168-184). Blood samples from the steers were taken at 50-day intervals throughout the trial. Compudose® steers gained a mean of 856 g/d compared with 710 g/d by control steers ( $P < 0.001$ ). The total fasted and unfasted LWG of treated steers was improved by 29.6 kg (20.5%) or 36.3 kg (25%), respectively, over the untreated steers. There were no significant ( $P > 0.05$ ) differences in the amount of herbage eaten between treated and untreated groups (7.4 vs 7.1 kg DM/hd/day). Feed conversion efficiency in the implanted group was improved by 15.7% over the untreated steers. Grazing behaviour, hormone and metabolite concentrations between treated and untreated steers were not significantly different ( $P > 0.05$ ). The use of Compudose® resulted in a net income of \$55 per implanted steer. In conclusion Compudose® implants proved to be a useful management tool to increase performance and productivity in finishing steers under New Zealand pasture-based systems.

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## LIST OF ABBREVIATIONS

A x (HxF)	Angus x Herford x Friesian
Cr	chromium
Cr <sub>2</sub> O <sub>3</sub>	chromium sesquioxide
CRC	Intraruminal chromium controlled release capsule
cm	centimetre
d	day
DOMD	Organic matter digestibility of the dry matter
DM	Dry matter
DMD	Dry matter digestibility
DMI	Dry matter intake
FO	Faecal output
GH	Growth hormone
h	hour
ha	hectare
hd	head
IGF1	Insulin-like growth factor 1
IU	International units
kg	Kilogram
LWG	Liveweight gain
ME	Metabolisable energy
MEI	Metabolisable energy intake
MJ	Megajoules
mg	milligram
min	minute
ml	millilitre
mm	millimetre
NEFA	Non esterified fatty acids
ng	nanogram
OM	Organic matter
OMI	Organic matter intake

OF	Oesophageally fistulated
SE	Standard error of the mean
vs	versus
W <sup>0.75</sup>	metabolic liveweight
µg	microgram

#### **Levels of statistical significance**

NS	Not significant
*	0.01 < P < 0.05
**	0.001 < P < 0.01
***	P < 0.001

## **CHAPTER ONE: INTRODUCTION**

### **INTRODUCTION**

World food production needs to increase as world population is predicted to double by the year 2100 to around 10 billion. To feed this population increase requires a 2.5-fold increase in food production per unit of land area (Robinson 1990). Furthermore, if this does not happen, then famine may become a truly global phenomenon as presently many of the world's people are not adequately fed (Wallace 1990).

Animal production is about food production. An important aim in animal production systems has been to improve animal performance, through more efficient production processes, that are cost-effective and ensure quality of product (VanderWal 1976; Heitzman 1983).

The efficient conversion of food into lean meat varies with stage of growth, being most efficient in the young animal and least efficient in the mature animal. Rate of muscle growth declines with advancing age and it is estimated that over 60% of the liveweight gain at maturity is represented by the deposition of fat (Roche & Quirke 1986). Accordingly, the ruminant animal converts at an early age more than 70% of the feed protein into body protein, and then with increasing age the conversion rate decrease to approximately 40-45 %. Hence, it is important to maintain a favourable feed conversion ratio in animals for the longest possible time (VanderWal 1976; Rumsey 1990).

Efficient meat production in beef steers is affected by growth rate, mature weight and composition of the growth the animal. Of these, growth rate is the factor that can be most easily controlled by the farmer (Morris 1994).

It has been widely demonstrated that bulls grow faster than steers which in turn grow faster than heifers or cows, while ovariectomised heifers grow the slowest

of all. This is a reflection of the fact that sexual status and hormone status are interdependent (Buttery 1985; Heitzman 1986; Hoffmann 1990).

Although bulls grow faster, require less feed per unit of gain and have a higher percentage of edible cuts in the carcasses than steers (Hopkinson et al. 1985; Calkis et al. 1986; Jonhson et al. 1986), there are some management difficulties with bulls, particularly at pasture (McKenzie 1983). Bulls also are prone to stress prior to slaughter, and pre-slaughter stress results in an increased incidence of dark cutting meat, which reduces the economic value of the carcass (Coop 1987). Moreover, meat from bulls has a higher collagen content than meat from steers which can lead to toughness particularly in meat from older bulls (Kirton & Morris 1987). Hence there are advantages in farming steers rather than bulls.

It is possible to manipulate growth rate in farm animals by the administration of sex steroid hormones in the form of subcutaneous ear implants (Heitzman 1976; Heitzman et al. 1984; Roche & Quirke 1992).

The use of growth promoters is a useful tool in growth management because they exert a positive effect on the efficiency of protein deposition (Buttery et al. 1978; Buttery 1985; Mader et al. 1991). These products have been used for over 30 years and can be classified into two broad groups, feed additives and anabolic implants. It has been estimated that in the order of 150 million of implants are used in the world annually (Simpson & Moore 1990).

Growth promoters improve growth rate and feed efficiency through systemic action on the hormonal, biochemical or metabolic processes of the animal, resulting in more efficient use of protein and reduction of the relative proportion of carcass fat (VanderWal 1976; Verbeke et al. 1976; Muir et al. 1977; Paterson & Salter 1985). Hormones currently used as growth promotants are the naturally occurring oestrogenic, progestagenic and androgenic steroids, and synthetic compounds with similar action (zeranol and trenbolone acetate). The selection of product to be used is based on a balance between those hormones which occur naturally at high levels in the animal and those which do not. Oestrogenic

compounds are effective in stimulating liveweight gains and improving feed efficiency of growing and finishing ruminants, particularly castrates. Under feedlot conditions liveweight gain and feed conversion are improved 14 to 17% and 10 to 12%, respectively, resulting in heavier carcasses, containing more protein, more moisture and less fat (Shamberev 1976; Trenkle 1976; Verbeke et al. 1976; Heitzman et al. 1984; Buttery 1985; Blackman 1990; Roche & Quirke 1992).

New Zealand has a temperate climate, with no distinct dry season and average temperatures in the warmer summer months are below 22 °C while winter temperatures are low enough to ensure that grasses have some dormancy (Baker et al. 1992). The predominant grass genera in these pastures are Lolium, Agrostis, Bromus, Festuca and Poa, and Trifolium and Medicago in legumes (Minson 1990). Of New Zealand's total land area of 27 million ha, two thirds is dedicated to agricultural production systems and a half is in established pasture (Neeley & Parminter 1993).

The New Zealand economy has for over 100 years depended upon the productive capacity of the farming sector to produce the country's prosperity (Thompson 1990). The great bulk of beef exports go to the USA as manufacturing beef to be incorporated with United States trimmings to reduce the overall fat level of the latter (Muir et al. 1992). On the other hand, some prime quality beef is airfreighted to markets in North Asia and South East Asia for the hotel and restaurant trade (Joyce 1992).

Thus, agriculture is the country's most significant source of income, and beef cattle production represents an important aspect (Neeley & Parminter 1993). Of the total New Zealand beef production (around 0.5 million tonnes) 55 % comes from beef cattle and 45 % from the dairy industry. Beef from the dairy industry comprises cull dairy cows and 800,000 male bobby calves slaughtered at 3-4 days of age for veal. A proportion of Friesian bull calves are reared through to 1-2 years of age as bull or steer beef. Most of the dairy beef is lean manufacturing grade beef (Coop 1987).



An important aim of New Zealand beef cattle producers is to improve the efficiency of beef production. Hormonal growth promoters are a useful management technique to increase growth rate and feed conversion efficiency in cattle under pastoral-based systems (Roche & Quirke 1992). Their use has been shown to increase financial returns (Simpson & Moore 1990), without any residue problems in animals or humans (Rico 1983).

Recently, New Zealand beef farmers have significantly increased their use of hormonal growth promoters in beef cattle. Forgie (1995) reported that in one slaughter plant the proportion of prime steers treated with implants increased from 33.84 % in 1993 to 52.24 % in 1994.

Experimental work in the use of hormonal growth promoters in New Zealand started in the early 1980's. McKenzie (1981) highlighted their positive effect on steer production and, later, McKenzie (1983) showed that the behavioural problems in finishing bulls at pasture can be overcome using implants (zeranol). In 1989, the growth promotant Compudose® containing the naturally occurring hormone oestradiol-17 $\beta$  was licensed for use in New Zealand. Farmer experience with Compudose implants suggests there are economic benefits from using this growth promoter (Bland 1991). However, there is little data available on its effects on growth rate and/or feed conversion efficiency and/or carcass composition in animals at pasture in New Zealand.

Therefore, this thesis was designed to evaluate the effect of Compudose® (oestradiol-17 $\beta$ ) on liveweight gain, herbage intake, grazing behaviour and circulating hormone and metabolite concentrations in steers grazing ryegrass-white clover pastures from late spring to late autumn. Additionally, the economic returns from using Compudose® in steers were evaluated.

# HERBAGE INTAKE AND GRAZING BEHAVIOUR IN BEEF CATTLE

## Introduction

The consumption of feed is the first step in the process whereby ruminants convert feed into human food and valuable products. However, the amount of feed which ruminants voluntarily consume profoundly influences the efficiency of this conversion process (Ketelaars & Tolkamp 1992).

Similarly, voluntary food intake in cattle has a large impact on performance, and the economic benefits of using optimal amounts of feedstuffs have increased the need for accurate feed management. A low voluntary food intake will result in a loss of body weight and hence a decrease in a productive process, such as growth. Conversely, if intake is too high then excessive fat deposition may occur and, because fat deposition implies a high energy content, it is expensive to produce and therefore costs of production increase (Forbes 1986).

There are a large number of factors determining the amount of feed eaten by ruminants under particular conditions. The factors influencing voluntary feed intake in housed animals appear to be mainly physical and metabolic ones, whereas in grazing animals it is affected by the animal, pasture, management and the environment (Holmes 1989).

The factors affecting herbage intake in grazing animals can be categorised into factors of sward origin (chemical composition, plant maturity, digestibility, herbage species, herbage mass), factors of animal origin (age, weight, size, breed, sex, condition), and factors of management origin (herbage allowance, climate, season, grazing system)(Meijs 1981).

## **Factors of sward origin**

### **Plant maturity**

The stage of maturity of plants has large impact on herbage intake of grazing animals. The proportion of cell wall components increases with increasing plant maturity, with a corresponding decrease in digestibility. Hence when the cell wall content of a forage increases, the digestion time and the duration of mastication per kg increases, resulting in a reduced intake (physical regulation of appetite) (Dulphy & Demarquilly 1994).

The chemical and physical properties of forages influence both the quantity of forage consumed and the nutrients which become available for metabolism in the grazing ruminant (Beever & Siddons 1984).

### **Digestibility**

In conditions where herbage quantity is not limiting, the herbage intake of grazing cattle is related primarily to the digestibility of the herbage consumed (Jamieson & Hodgson 1979).

With feeds of lower digestibility, intake is limited by physical factors, in particular by distension of the rumen. With these feeds, a linear increase in voluntary feed intake occurs with an increase in digestibility. Conversely, with feeds of higher digestibility voluntary feed intake is probably limited by the energy requirements of the animal and its ability to metabolise absorbed nutrients. With these feeds, the quantity eaten decreases as digestibility increases so that the quantity of digestible energy remains constant (Holmes & Wilson 1987).

As was pointed out by Ellis (1978), voluntary intake will increase with increasing digestibility of the ration until a certain point where digestibility and intake reach

an equilibrium - that is, when the supply of nutritive energy is equal to the animal's capacity to utilize it.

Thus, improvement of herbage digestibility may confer a double advantage on the grazing animal - an increase in nutrient concentration of the diet and, at the same time, an increase in the amount of feed eaten (Hodgson 1990).

### **Herbage species**

The relationship between digestibility and intake may differ for different herbage species. When species are compared at the same level of digestibility, intake is often not necessarily the same (Holmes 1989).

It has been demonstrated that voluntary feed intake is higher for annual ryegrasses and white clover than for perennial ryegrasses, and higher for leaf than for stem in feeds of the same digestibility (Ulyatt 1981).

Furthermore, different plant species or components can differ in their rate of digestion at similar levels of digestibility. Legumes have a lower ratio of cell wall material to cell content than grasses at any given level of digestibility. Therefore both the rate of digestion and the amount eaten are usually higher in legumes than in grasses (Minson 1982).

### **Herbage mass**

The relationship of herbage intake to herbage mass or herbage availability is curvilinear in nature. In the ascending part of the curve, the ability of the animal to harvest pasture (non-nutritional factors) appears to be the most important in limiting intake. These factors are influenced by plant maturity and structure, and by the grazing behaviour of the animal. In this part of the curve, herbage intake is very sensitive to changes in the amount of herbage allocated. At the

asymptotic section of the curve, nutritional factors such as digestibility, the time feed stays in the rumen and concentration of metabolic products appear to be the most important in controlling intake (Poppi et al. 1987).

Consequently, the factors that influence herbage intake are herbage mass, through its influence on herbage height and/or sward density, and the components of plant structure. Together these influence the ease with which the animal canprehend herbage together with the rate of daily herbage intake (Hodgson 1985).

When herbage of adequate quality is available in adequate quantity, intake is closely related to animal factors such as the size of the animal and its potential production level (Holmes 1989).

### **Factors of animal origin**

There are two groups of intrinsic stimuli that may provide feedback to the central control system to limit food intake in cattle. These are stimuli arising from the process of absorbing and metabolising nutrients from the ingested food (metabolic control) and stimuli arising from distention of the alimentary tract by the physical presence of food (physical control)(Forbes 1986).

Furthermore, the ability of the alimentary tract to accommodate more food is directly related to the extent of digestion, the rate at which the products of digestion are absorbed, and the rate at which undigested residues pass through the tract (Korver 1982).

## **Animal weight and age**

Liveweight and size of a growing animal are highly correlated. The larger and heavier the animals, the greater is the capacity of the alimentary tract for food consumption (Meijs 1981).

There is an upper limit to voluntary feed intake set by the animal's potential requirement for dietary energy which is related to the liveweight of the animal (Holmes & Wilson 1987).

Invartsen (1994) found that, in Holstein-Friesian bulls fed concentrates ad libitum, intake was 96 g per kg  $W^{0.75}$  at 100 kg liveweight, increased to maximum of 106 g at 170 kg, and then declined to 86 g at 500 kg liveweight. Increasing fatness therefore decreased feed intake per kg of metabolic weight. Likewise, as animals age they eat proportionally less, but this may be an effect of liveweight rather than of age per se (Holmes 1989).

Similarly, Hodgson (1990) has pointed out that young, rapidly growing animals eat more per unit live weight than mature animals with little growth potential.

## **Animal condition**

Intake capacity of ruminants is influenced by their body condition or fatness. As thin animals become fat, intake decreases. Younger animals will compensate for previous periods of under-nutrition by eating more per unit liveweight than animals which were previously well fed (Forbes 1986).

The reduction in intake of fat cattle has been attributed to the restricting effect of abdominal fat on the rumen. However intake of concentrates was also reduced in fat animals, when the rumen was not filled to capacity (Holmes & Wilson 1987).

## **Factors of management origin**

### **Herbage allowance**

Herbage allowance is the weight of herbage (DM or organic matter) present per unit of animal weight (or  $W^{0.75}$ ) (Hodgson 1984). However, herbage allowance is more precisely defined as the quantity of the herbage allocated to animals per unit of time (Meijs et al. 1982).

It appears that the relationship between allowance and intake is modified by maturity of the herbage. Thus, in older herbage the allowance required to reach maximum intake is higher than in younger herbage (Meijs 1981).

Intake normally approaches a maximum at allowances 3 to 4 times greater than the amount eaten, but only starts to decline markedly when the allowance is less than twice intake. A reduced allowance may also depress the digestibility of the herbage consumed, but this will usually have a smaller impact on performance than direct limitation of herbage intake (Minson 1990).

Consequently, as stocking rate increases, grazing pressure rises accordingly and, as herbage allowance falls in quantity and quality, competition between animals increases and the opportunity for the animals to select from the pasture is reduced. This results in a reduction in intake and progressively the animal is prevented from satisfying its nutrient requirements. An inadequate herbage allowance is the most common reason for low production per animal from pasture (Holmes 1989).

Grazing animals are subject to a continually changing pattern of food supply. At times food supply is restricted due to a low pasture growth or because food supply is deliberately rationed to conserve material for more critical periods of the production cycle (Freer 1981).

At low herbage allowances non-nutritional factors are important determinants of intake because, under these conditions, there is increased difficulty of harvesting herbage leading to depressed intakes (Poppi et al. 1987).

Thus, a close relationship between nutrient intake and performance of grazing animals exists. Moreover, the structural characteristics of the sward appear to have a direct impact upon the ingestive behaviour of animals through the amount of herbage prehended per bite (Hodgson 1990).

Animals appear to respond primarily to variations in the amount and maturity of leaf material in the sward and its distribution within the sward canopy (Jamieson & Hodgson 1979). Thus, for swards maintained in a steady state, sward canopy height appears to be the characteristic which best rationalizes animal production responses over sites, years and seasons (Hodgson 1985).

However, variations in height and bulk density are often confounded with considerable differences in leaf size, spatial arrangement, age and strength, stem height and leaf to stem ratio, and the degree of dead matter (Mitchell et al. 1991).

Sward surface height has been shown to be an important grazing tool in determining beef cattle performance at pasture. Hodgson (1985) pointed out that the liveweight gain of finishing cattle increased with increasing sward surface height to a maximum of 8-10 cm. Further increases beyond these levels will not improve animal performance but can lead to a reduction in sward density and herbage quality.

Additionally, sward surface height has been used by other researchers to determine animal performance under grazing conditions, for example in bulls (Morris et al. 1993a), in bulls and steers (Morris et al. 1993b), or in heifers (Khadem et al. 1993). These researchers have clearly demonstrated the positive relationship between sward surface height and cattle liveweight gain both within and between seasons.



## **Climate**

Temperature not only affects herbage intake but also influences the quality of feed. High temperatures increase the concentration of fibre in forages which subsequently reduces dry matter digestibility (Ulyatt 1981).

High ambient temperatures depress intake through their effect on the animal itself and by modifying grazing activities, namely confining grazing to early in the morning or late in the afternoon (Meijs et al.1982). In temperate regions, however, no relationship has been found between air temperature and grazing time, even over a wide temperature range (Baker et al. 1992).

In general, in temperate areas, the herbage species tend to be higher in essential nutrients than in tropical areas. This characteristic leads to low heat generation in fermentative digestion and also in metabolism, resulting in a better efficiency of nutrient utilisation and high levels of herbage intake (Leng et al. 1993).

## **Season**

Marsh (1975) found large differences in the intake of the steers consuming spring and autumn herbage in New Zealand. These variations in intake were associated with differences in the digestibility of the herbage and the efficiency of utilisation of metabolisable energy. However, it has also been reported that, at comparable levels of digestibility, the herbage intake of steers in autumn could be 14 % lower than in spring (Meijs 1981).

Reid (1986), working with beef cattle in New Zealand, reached a similar conclusion. He determined that pasture allowances required for maintenance or for maximum growth rate of beef cattle are higher in autumn/winter than in spring. Maximum animal growth rates during autumn/winter are only half of those obtainable in spring.

Possible causes of these differences in intake between seasons can be found in the intake-regulating factors which vary during the grazing season: animal factors, composition of the herbage, dead material and dry matter content, fouling by excreta, climatic conditions, day length, herbage availability, and composition of the dietary carbohydrates (Minson 1990).

In relation to sward characteristics, it has been reported that spring swards generally contain lower tiller population densities and greater leaf extension rates than summer and autumn swards (Hodgson 1990). With these characteristics of the sward, high levels of herbage intake of grazing animals are achieved and, therefore, better performances are recorded.

### **Grazing system**

In grazing systems, the interactions between herbage growth and utilisation exert an important influence on animal performance, and ultimately on production efficiency. Grazing animals may affect the rate of herbage growth by removing plant material from the sward, by direct physical damage to plants or soil, or by recycling plant nutrients through excretion in faeces and urine. Conversely, grazing animals can be affected by the amount of herbage eaten and the nutritive value of the herbage (Hodgson 1990).

The most common methods of grazing management are continuous stocking, in which animals are continuously present on a sward for several weeks or even for the whole grazing season, and methods involving intermittent grazing (rotational grazing, strip grazing) in which an area of pasture is grazed down quickly and the animals are moved once (or twice) daily to once a week. Set stocking is a special case of continuous stocking in which a fixed number of animals remain on specified area for a prolonged period of time (Hodgson 1990).

Independent of the grazing system used, grazing animals are often forced to graze to a low post-grazing herbage mass in order to maximize output per

hectare or to ration pasture over times of shortage. As a consequence intake is depressed (Poppi et al. 1987).

## **Grazing Behaviour**

Under normal conditions free-ranging animals spend several hours each day in foraging activities. Periods of active grazing of variable length and intensity are interrupted by many other individual and herd activities. Within a single grazing session, herbage intake firstly alleviates hunger and then gradually induces satiation, dismissing the eating drive and, ultimately, resulting in the cessation of grazing (Dougherty et al. 1989).

The amount of herbage eaten daily by grazing animals has been calculated as the product of the time spent grazing, the rate of biting during grazing and the weight of herbage consumed per grazing bite. From this relationship it is possible to estimate two other components of grazing behaviour, total number of grazing bites per day (the product of grazing time and rate of biting), and the rate of herbage intake (the product of rate of biting and intake per bite (Hodgson 1982). It has been seen that high growth potential in young animals increases grazing time and rate of intake. Commonly, thin animals have higher rates of intake (through increasing biting rate) than fat animals (Black 1990).

It is important to recognise, however, that other components of grazing behaviour such as rumination, walking and drinking, may directly affect aspects of grazing activity and energy expenditure. Moreover, the duration and extension of these activities are influenced by sward conditions, grazing management and climatic variation (Hodgson 1990).

Grazing time rarely exceeds 12-13 h per day, as beyond this grazing would interfere with rumination and other behavioural requirements. In general, it has been pointed out that cattle expend between 5.8 and 10.8 h per day in grazing (Hodgson 1985).

Biting rate is partially determined by the time required to process (bite, chew and swallow) forage and by the time spent in selection and movement (Burlison et al. 1991). The range in biting rate in cattle has been calculated to be around 20 to 60 bites per minute (Hodgson 1985).

## **METHODS OF ESTIMATING HERBAGE INTAKE**

### **Introduction**

The techniques used to estimate herbage intake of grazing animals can be divided into those that estimate the loss from pasture, or pasture-based methods, and those that estimate the gain to the animal, or animal-based methods (Greenhalgh 1982).

### **Pasture-based techniques**

Pasture-based methods for measuring herbage intake are founded on the principle that the difference between herbage present at the start and end of the grazing period is taken to represent the total herbage intake of the animals. It requires herbage mass to be estimated at the beginning and at the end of the grazing period. The difference between the two gives an estimate of the apparent quantity of herbage consumed per unit of area. The calculated consumption is then converted to intake per animal per day by dividing by the number of animal-days per unit area (Meijs 1981).

Accordingly, pasture methods can be classified as destructive (cutting at different levels) and non-destructive (visual, height and/or density) methods (O'Sullivan et al. 1987).

## Cutting techniques

All measurements of herbage mass involving cutting and weighing are influenced by the method, height and frequency of cutting, and by the grazing management employed during cutting. These factors interact with plant growth and therefore influence dry matter (DM) yields (Radcliffe 1971).

Three cutting techniques have been developed to approximate normal grazing management. They are cutting at a field-scale mowing level (5 cm, low/moderate grazing), cutting at lawnmower level (3 cm, moderate/high grazing), and cutting to ground level (0 cm, high grazing), the latter being preferred because it minimises sampling error (Meijs et al. 1982).

Sward cutting methods impose little interference on the animal per se, but their applications are limited to specific grazing situations and they can only provide an estimate of the mean intake of a group of animals (Le Du & Penning 1982).

In many situations it is desirable or essential to estimate herbage mass without cutting or destroying the herbage. Non-destructive techniques involve the measurement of one or more sward characteristics in the grazing area before and after grazing, combined with a prediction of the herbage mass using an appropriate regression equation (Stephen & Revfeim 1971).

## Ellinbank rising plate meter

The Ellinbank rising plate pasture meter consists of a 300 x 300 mm horizontal plate with a downward pressure of 5 kg/m, achieved through a vertical shaft of one meter length, along which the horizontal plate passes freely. As the shaft and plate are lowered into the pasture, the plate rises relative to the shaft and the distance is recorded on a ratchet counter mounted adjacent to the shaft. Any number of measurements can be made (in general 50 per paddock are

recommended) and the cumulative reading recorded at the end of a series of readings (McGowen & Earle 1978).

### **HFRO sward stick**

The HFRO sward stick was designed to estimate sward surface height in an easy and objective manner. It contains a 2 x 1 cm window attached to a sleeve which slides on a 1 cm<sup>2</sup> rod marked with recordings at 0.5 cm bands. The standard rod is 45 cm long. For each measurement the base of the rod is placed on the ground and the sleeve is lowered until the base of the window is seen to make contact with any part of a lamina. On contact, the sleeve is clamped to the graduated rod and the height read. This process is repeated at different sites until sufficient records (30-40 per paddock) have been collected (Barthram 1986).

Both pasture meters are calibrated by relating the meter readings of a number of quadrats to the herbage DM yield of these quadrats cut to ground level. A simple linear regression relationship determines the herbage yield (Michell 1982):

$$Y = a + bH$$

Where: Y = DM yield (kg/ha)

H = mean meter height (cm)

a,b = constants estimated by regression

The precision of these sward-based methods is adversely affected by increasing heterogeneity of the sward. This may be due to different botanical composition, soil structure and composition, supply of fertilizers and water, selection by the animal between herbage species, plant parts or contaminated herbage areas, and to the intensity of defoliation of the sward (Piggot 1986).

Furthermore, it has been found that one of the major sources of variability in pasture grazed by animals is the close aggregation or greater growth of plants in 'clumps'. These are usually scattered over the paddock and can occupy up to 10% of the total grazing area (Stephen & Revfeim 1971). These 'clump' areas tend to yield more highly than the surrounding regions. Thus the smaller the size of a pasture sample the less is the likelihood that samples will take sufficient account of these areas and therefore the yield estimate is likely to be lower than the actual yield. The location of sampling sites becomes important and placement decisions are forced on an observer in light of the need to cover the area in as representative a manner as possible. The mean reading obtained will, therefore, be a reflection of the observer's ability to take an accurate account of this 'clumping' effect. The more completely detached their placement decisions are, the greater will be the likelihood of lower yield estimates, whereas over-emphasis with regard to the 'clump' areas will give rise to estimates higher than the actual herbage yield (Stephen & Revfeim 1971).

Consequently, sward techniques are more appropriate in systems where grazing periods are relatively short, and where grazing pressures are high (eg. paddock or strip grazing systems)(Meijs 1981).

The main disadvantage in using pasture-based techniques for estimating herbage intake is that they do not yield direct information on the nutritive value of the herbage consumed (Corbett 1960).

### **Animal-based techniques**

Animal-based techniques can be used indoors through direct measurement of intake for feed evaluation studies or outdoors through indirect measurements using a faecal marker to estimate faeces production together with an estimate of herbage digestibility of the diet selected by the grazing animal (Le Du & Penning 1982).

Indirect methods for the measurement of herbage intake have been based on the precept that the quantity of dry matter excreted in the faeces of a grazing animal can be measured and, if the digestibility of the food dry matter is known, then intake can be calculated. The expression used to calculate herbage intake from estimates of faecal output and diet digestibility is obtained from a simple manipulation of the digestibility relationship (Greenhalgh 1982):

$$\text{Digestibility} = \frac{\text{Faecal output}}{\text{Intake} - \text{Faecal output}}$$
$$\text{Intake} = \frac{\text{Faecal output}}{1 - \text{Digestibility}}$$

Measurement of herbage intake is therefore dependent upon an accurate estimation of the faecal output and digestibility of the herbage consumed. Note that errors in estimating digestibility induce large errors in estimates of intake and tend to increase as digestibility values increase. For instance, an error of 1 unit in digestibility induces errors of 5.0, 3.3, 2.5 and 2% in organic matter intake (OMI) at values of 80, 70, 60 and 50% digestibility, respectively (Langlands 1975).

### **Measurement of faecal output**

Faecal output can be estimated directly using faecal collection equipment attached to the animal. Errors arise from incomplete collection of faeces and from the effects of the equipment on animal grazing behaviour and hence intake (Meijs 1981).

Indirect estimation of faecal output can be achieved by an indigestible indicator or marker. This technique is based on the ratio between the quantity of marker released daily (or administered daily) into the rumen and the average daily concentration of the marker in a sample of the faeces. The most common markers



are chromium oxide, Cr-EDTA, anthraquinone violet dye, and polyethylene glycol (PEG) (Le Du & Penning 1982).

The most widely used marker is chromium sesquioxide ( $\text{Cr}_2\text{O}_3$ ) or chromic oxide. It has been found that the form in which chromium is administered influences the degree of diurnal variation in faecal Cr concentration. Other factors affecting the magnitude of the diurnal variation include the frequency of dosing, pattern of feeding and quality of feed consumed (Parker et al. 1989).

Using a marker, faeces output from the animal can be estimated from the following equation (Le Du & Penning 1982):

$$\text{Daily faeces output (g)} = \frac{\text{Weight of the marker given (g/day)} \times \text{RR}}{\text{Mean conc. of the marker in faeces (g/g)}}$$

Where, RR is the recovery rate of the marker and is:

$$\text{RR} = \frac{\text{Total weight of the marker excreted in faeces (g)}}{\text{Total weight of marker given (g)}}$$

Administration of chromic oxide by the intraruminal chromium controlled release capsule (CRC) has reduced the high labour requirement formerly required for daily dosing of chromium as impregnated paper or gelatin capsules, and reduced diurnal variation through uniform continuous chromium oxide release into the rumen. The capsules have a plastic barrel into which a matrix of  $\text{Cr}_2\text{O}_3$  in sucrose mono-stearate (65:35 w/w) is inserted (usually as a series of tablets). This is followed by a plastic plunger and a compressed steel spring. An orifice, of variable size, exposes the matrix to the rumen contents, forming a gel which is extruded through the force of the spring and by gaseous exchange across the barrel. A plastic strip, folded

against the barrel for dosing, opens into a T-configuration (wings) to retain the CRC in the rumen (Parker et al. 1990a).

The time required for chromic oxide to equilibrate through the gut is influenced by the level of intake and by the characteristics of the feed, as the rate of excretion of the marker is related to the rate of passage of digesta through the alimentary tract. Attainment of steady state conditions is usually not achieved until about day 5-6 after capsule administration in cattle (Nasution 1990).

Controlled release capsules are administered orally by a dosing gun, which releases the capsule at the back of the tongue. The swallowing motion of the animal then carries the capsule into the rumen. Alternatively, capsules can be placed down the oesophagus within a lubricated flexible rubber tube and released at the thoracic inlet (Parker et al. 1990a).

The advantages of a single CRC application are to provide a sampling period of up to 18 days and low diurnal variation of  $\text{Cr}_2\text{O}_3$  concentration in faeces. Faecal samples from individual animals can be collected at any time of the day without reducing the degree of accuracy of the chromium recovery. Also, CRC have the advantage of being less labour demanding than twice daily administration of  $\text{Cr}_2\text{O}_3$  in the form of either gelatin or impregnated paper (Hirschberg et al. 1990).

However, it has been found that regurgitation of the CRC can occur in some animals (15% of grazing cows) and an irregular pattern of chromium release also is possible (Nasution 1990). Regurgitation seems to be a greater problem in animals weighing over 450 kg liveweight (Parker 1990).

It is assumed that the administration of controlled release capsules does not influence intake - i.e. animals dosed with capsules have identical intakes to those of untreated animals. However, Parker et al. (1990b) found that the mean faecal DM output in sheep was lower (20-40%) in CRC-treated animals than in non CRC-treated animals.

## **In vitro digestibility measurement**

Digestibility cannot be measured directly (in vivo) in the grazing animal and therefore a number of indirect methods have been developed. These techniques include in vitro digestibility estimation using rumen microorganisms, in vitro digestibility using an enzyme preparation, and the nylon bag or in sacco technique. All techniques are usually calibrated with forage samples of known in vivo digestibility (DMD or OMD) (Langlands 1975).

The in vitro digestibility estimation using rumen microorganisms and pepsin, also known as the two-stage in vitro method, is considered to be an accurate technique for estimating the digestibility of forage dry matter (DM) and organic matter (OM). It is suitable for mixed samples containing different proportions of grasses and legumes. The technique involves fermentation of a sample with rumen microorganisms within a buffered medium under controlled anaerobiosis, temperature, and pH. The herbage sample is fermented for 48 h with rumen fluid inoculum, and then digested for a 24 h period with 2% pepsin-HCL. The inclusion of the acid-pepsin stage removes the crude protein remaining after the microbial digestion and reduces the residual standard error (Minson 1990).

The major difficulty associated with this procedure is the degree to which samples analysed actually represent feed consumed by the grazing animal. Likewise, the type of rumen liquor used and its relationship with the diet consumed can also affect the reliability or accuracy of the estimates of digestibility obtained (Meijs et al. 1982). Therefore, collection of samples representative of the herbage consumed is essential to the success of the in vitro technique. Herbage samples can be obtained by using surgically prepared animals, fistulated at the oesophagus or in the rumen, or by the use of 'hand-plucking' herbage once the experimenter has closely observed the grazing patterns of the animals (Le Du & Penning 1982). Oesophageally fistulated (OF) animals are not always available and their acquisition and day to day management may be too expensive and laborious (Meijs et al. 1982).

Therefore, hand-plucking may offer a low cost, easier, quicker, and reliable alternative. This requires the collector to observe precisely what plants and part of plants the cattle are eating and then to mimic this selection by plucking herbage between thumb and forefinger, so as to simulate grazing. However, the possibility of operator-biased sampling and the risk that samples may not represent the diet actually selected by the animal may limit the use of this method (Wallis de Vries 1990).

Le Du & Penning (1982) reported that animals often appear to select material of higher in vitro digestibility and nitrogen percentage than the experimenter. Furthermore, hand-plucking seems to underestimate digestibility when the diet is of low herbage quality and overestimate the digestibility value when herbage quality is high.

Once collected, the samples of herbage should be frozen quickly to prevent deterioration, and then stored to await drying, processing and analysis. It is important that all samples for chemical analysis should be freeze-dried rather than oven-dried, to minimise the loss of volatile components, especially water-soluble carbohydrates and nitrogen. Freeze-dried samples should then be ground through a fine sieve (eg. 0.8 mm), to ensure thorough mixing and consequently allow a representative sub-sample to be taken for analysis (Le Du & Penning 1982).

An alternative method to estimate herbage intake in grazing animals is the use of indigestible plant components or internal markers. N-alkanes, predominantly odd-chain compounds in the range C<sub>25</sub>-C<sub>35</sub> and present in the plant cuticular wax, can be used to estimate faecal output and therefore herbage intake in individual animals (Dillon & Stakelum 1990; Stakelum & Dillon 1990).

It has also been shown that use of alkanes enables the partitioning of the total intake of the grazing animal into its component plant species or plant parts (Dove 1993).

In addition, Mayes et al. (1986) have pointed out that n-alkanes offer potential advantages over in vitro or index techniques in that digestibility can be directly estimated in vivo. Consequently, it is possible to obtain an individual digestibility and faecal output value for each animal, and so an unbiased estimate of herbage intake.

## **GROWTH PROMOTERS**

### **Definition and classification**

Growth promoters are substances other than dietary nutrients that increase growth rate and/or improve feed efficiency and/or carcass quality in healthy animals under appropriate nutritional management (Fiems et al. 1991).

The term "growth promoters" can refer to several types of substances used in animal production e.g. antibiotic compounds, ionophores, probiotics, steroid hormones, growth hormones and  $\beta$ -agonists (Heitzman et al. 1984).

The steroid hormones can be divided into endogenous steroids which include the natural sex hormones oestradiol, progesterone and testosterone, and the synthetic steroids (or xenobiotics, which do not occur naturally in man or animals) such as trenbolone acetate and zeranol. Natural and synthetic hormones are also known as "anabolic agents" because of their mode of action (Hoffmann & Blietz 1983; Heitzman 1986; Hoffmann 1990).

## **Mode of action**

The manner in which nutrients are partitioned toward tissue growth, and the efficiency with which they are used for this process, is under control of the endocrine system. Modification of the endocrine system may be used to alter the partitioning process, so changing the relative rates at which tissues are synthesised (McCutcheon 1989).

Anabolic agents, through their action on the pituitary gland, may act indirectly on the muscle or fat cell by changing the concentrations of other endogenous anabolic and catabolic hormones e.g. growth hormone, insulin, prolactin, thyroxine, triiodothyronine and corticosteroids (Heitzman 1983; Schanbacher 1984).

Although the mode of action of oestrogenic growth promoters cannot be completely explained it is likely to be at least partly indirect, i.e. mediated via other hormones. Nevertheless, oestrogen receptors have been found in skeletal muscle indicating that this hormone could bind to muscle cells and directly influence their growth (Meyer & Rapp 1985).

Normally, the metabolism of the three major metabolic fuels (carbohydrates, lipids and proteins) is affected by growth hormone (GH). This acts as a counter-regulatory hormone to insulin, inducing hyperglycaemia, stimulating lipolysis and inhibiting lipogenesis. These processes may serve to redistribute metabolic fuels to the tissues requiring them, although such redistribution has been observed in the absence of the classic lipolytic and diabetogenic effects of GH. Growth hormone also has important effects on protein and amino acid metabolism (Davis et al. 1984).

Insulin is considered a secondary growth regulating hormone and one which has more acute effects. It stimulates amino acid uptake, increases the synthesis of glycogen, fatty acids and proteins, decreases proteolysis, and enhances lipogenic activity (redirection of energy into fat stores). Therefore insulin is likely to be involved in regulation of muscle growth (Riis 1983).

Thyroxine has been implicated as the anabolic effector of growth promoters. However, since thyroxine has so many different effects upon tissue metabolism it is difficult to define an action due solely to an anabolic agent (Trenkle 1976; Buttery et al. 1978).

Anabolic agents probably achieve their effect by causing a net increase in nitrogen retention in the form of muscle protein, through increasing the rate of protein synthesis and decreasing the rate of muscle catabolism. The net result is an increase in muscle and bone formation at the expense of fat deposition. Accordingly, plasma concentrations of both essential amino acids and urea (a byproduct of proteolysis) are reduced in steers treated with oestrogenic compounds (Heitzman 1978; Heitzman 1983; O'Callaghan et al. 1988 ).

Since the energy required to synthesise protein or bone is less than that required to synthesise the same weight of fat, and the amount of water in muscle is greater than in body fat, it follows that a given amount of food will produce a higher liveweight gain in a hormone-treated than in an untreated animal due the greater value of protein deposition in the former (McDonald 1979).

### **Growth promoters in beef cattle**

The importance of steroids in regulating the growth process is evident from the differences between males and females in body growth and composition, especially after puberty (Kirton 1989). Castration of males, which removes their principal source of androgens, is the most basic method of manipulating growth by non-nutritional means (Unruh 1986).

Bulls grow faster than steers by 10-20%, have higher feed conversion efficiency and yield more lean meat. However, the major reason against farming bulls is their behavioural problems, namely riding, pasture and fence damage, and physical damage to the bulls themselves (McKenzie 1983).

Castration prevents unwanted matings, produces a more desirable carcass for the market place, and make males more placid and therefore easier to manage (Kirton & Morris 1989). However, this practice also reduces liveweight gain and increases fat deposition within the carcass. One way to lessen the negative impact of this management practice is to administer hormones with growth promoting activities (Schanbacher 1984).

In cattle the principle dictating the type of hormone to be used is the need to supplement or replace the particular hormone type which is considered deficient in the target animal (Roche & Quirke 1986).

Hormone treatment of castrated male and female cattle tends to increase the proportion of lean meat and to decrease that of fat, while treated entire males show increased fat deposition (Patterson & Salter 1985; Lemieux et al. 1988; King et al. 1992).

Efficiency of feed conversion has also been improved by oestrogen administration. This improvement in feed conversion occurs because lean tissue can be deposited with a lower energy cost per unit wet weight than fat, and because animals which grow rapidly to slaughter weight use a relatively low proportion of their energy intake for maintenance (McCutcheon 1989).

Additionally, it seems that hormonal treatment does not increase the amount of feed consumed appreciably (McDonald et al. 1979). On the other hand, it has also been suggested that, following oestrogen treatment, voluntary feed intake may increase (McCutcheon 1989; Rumsey 1990; Mader et al. 1994). However, most of the trials have investigated improvements in growth rate and efficiency under feedlot conditions and there is little information about the effect of growth promotants on herbage intake in beef cattle grazing pastures.

In general, with anabolic agents there are improvements of about 10 to 15% in growth rate and about 8 to 10% in feed conversion efficiency under feedlot conditions (Basson et al. 1985; Calkins 1986; Mader et al. 1994). The effect of



growth-promoting implants in grass-finished cattle has resulted in an increase of 5-30% in liveweight gain (Baker et al. 1992). Under New Zealand pasture feeding cattle systems, liveweight responses of between 10-30% have been recorded in steers and heifers (McKenzie 1981; Bass 1989).

Consequently, the major effects arising from the use of anabolic agents in meat production are manifest primarily in improvements in growth performance, with lesser effects being apparent in carcass composition. Meat quality is not adversely affected by anabolic agents in terms of taste, colour, tenderness, flavour or collagen content (Patterson & Salter 1985; Roche & Quirke 1986).

### **Compudose®**

Compudose® was licenced for use in New Zealand in 1988. It is a growth promotant for use in steers and contains the steroid hormone oestradiol-17 $\beta$  in a silicone rubber implant. Compudose® containing 24 or 45 mg of oestradiol-17 $\beta$  (for 200 or 400 days treatment, respectively) is implanted under the skin in the middle third of the ear (there also is 100 day version available for feedlot cattle in Australia and the USA)(Figure 1.1). Compudose® does not have a withholding period. The advantage of using this product may represent an increase in liveweight gain of up to 23% under pasture feeding conditions (Elanco Products, N.Z.).

The 200 and 400 days implants enable minimal animal handling for re-implantation during the finishing period where other implants like trenbolone acetate (Apple et al. 1991) and zeranol (Simpson & Moore 1990) need to be re-implanted every 75-90 days.

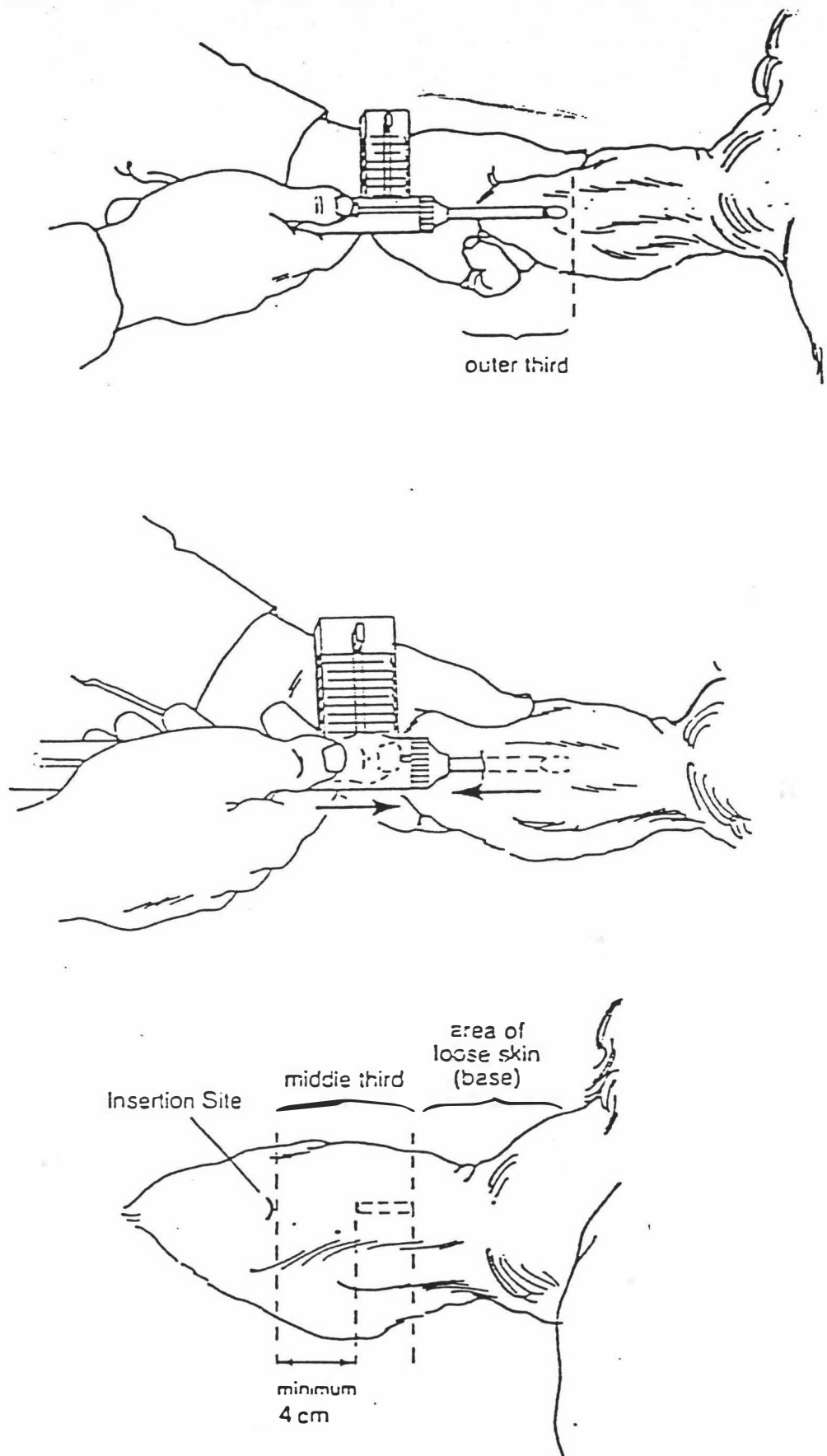


Figure 1.1 The Compudose® implants should be deposited under the skin on the back side of the middle third of the ear (Elanco Products, NZ).

## Safety

The issue of hormone residues in meat has been the greatest cause of controversy in regard to use of growth promoters. The major concern is that anabolic agents administered to animals, or their metabolites, may remain in the meat and affect the human hormonal or endocrine status or induce cancer (Heitzman 1986; McCutcheon 1989).

Endogenous anabolic steroids are hormones synthesised primarily in the ovaries and testes, or in the placenta of adult females. These molecules are transported in the blood plasma bound to specific or nonspecific proteins. Only the free (not bound to protein) fraction is active on the target organs and takes part in hypothalamo-hypophysial feedback. Catabolism of anabolic steroids may occur by oxidation, reduction and hydroxylation, and conjugation of the steroids with an acid (eg. glucuronic or sulphuric). The resulting water-soluble compounds are then excreted. Transformations of the hormone molecules take place in the liver, and result in a loss of activity that is usually irreversible. The half-life of these compounds is short (< 0.5 h), which implies a high metabolic clearance in relation to the intense activity of liver biotransformations (Henricks et al. 1983; Rico 1983).

Ruminants transform oestradiol-17 $\beta$  into oestrone, and then to the biologically low activity compound oestradiol-17 $\alpha$ . This form is mainly excreted by the kidney and in free form in the faeces (60-70%) and the remainder is excreted either as the glucuronide or sulphate (Rico 1983; Roche & Quirke 1992).

Endogenous steroids therefore, have a low bioactivity when consumed orally, largely because they are readily biodegradable when entering the enterohepatic circulation in man and animals (Hoffmann 1984).

Furthermore, humans have, for most of their existence, eaten animal tissue with high concentrations of endogenous hormones such as oestradiol in pregnant cow muscle (pregnancy leads to an increase of oestradiol and oestrone by a factor of

up to 200 not only in plasma but also in tissues), and testosterone in bull muscle (Table 1.1)(Heitzman et al. 1984).

Table 1.1 Human intake of anabolic steroids from meat compared with their endogenous production in humans of various ages (Heitzman et al. 1984).

Production in humans ( $\mu\text{g}/\text{d}$ )	Testosterone	Oestrogen	Progesterone
Adult male	6480	136	416
Women			
during cycle	240	190-1600	418-19600
late pregnant	320	64300	294000
post-menopausal	140	46	326
Pre-pubertal child	32	42	150
<b>Maximum amount of hormone (<math>\mu\text{g}</math>) in 250 g meat</b>			
Untreated cattle	0.13 <sup>a</sup>	0.11 <sup>b</sup>	2.5 <sup>b</sup>
Treated steer	0.0006	0.005	0.15
Treated heifer	0.025	0.005	-

<sup>a</sup> Mature bull.

<sup>b</sup> Pregnant cow.

Table 1.1 shows that treated steers and heifers commonly exhibit levels of anabolic steroid residues considerably lower than those occurring naturally in mature bulls and pregnant cows. Moreover, the levels of steroids which could be ingested by eating meat are several orders of magnitude lower than those produced within the human body.

In addition, Bass (1989) has pointed out that the level of steroid hormones in 500 g of meat from treated cattle is 200 times less than the level present in an egg and 3-5 times less than the level found in a glass of milk.

Oestrogenic substances (phytoestrogens) can also be found in some vegetable and fruit products (Lindner 1976). Vegetable oil containing phytoestrogens can hold 100,000 times more oestrogen than meat from veal calves treated with an oestrogenic implant (Maghuin-Rogister 1991).

Until now, no scientific evidence has been provided to show that the use of growth promoters (hormonal products) in cattle imposes a health hazard to the consumer when they are used correctly (Hoffmann 1990).

## CHAPTER TWO

### THE EFFECT OF OESTRADIOL-17 $\beta$ (COMPUDOSE®) ON LIVELINE GAIN, HERBAGE INTAKE AND CIRCULATING HORMONE CONCENTRATIONS IN STEERS AT PASTURE

#### ABSTRACT

Efficient conversion of pasture to beef is a key ingredient of profitable production. Oestrogenic compounds (Compudose®) under feedlot conditions have improved liveweight gain in 14-17% and feed conversion efficiency in 10-12%. There is little information available on feed intake and hence efficiency of liveweight gain under New Zealand pastoral systems. Therefore, the objective of this study was evaluate over a 203 day period the effect of Compudose® on liveweight gain, herbage intake, grazing behaviour and circulating hormone and metabolite concentrations in steers grazing ryegrass-white clover pastures. Twenty 14-month-old Friesian steers and sixteen 14-month-old Angus cross were randomly assigned within breed to either Compudose® or no-Compudose®. Fasted and unfasted liveweight gains (LWG) of the steers were recorded as was herbage intake and grazing behaviour, measured on two occasions (days 34-50 and days 168-184). Blood samples from the steers were taken at 50-day intervals throughout the trial. Compudose® steers gained a mean of 856 g/d compared with 710 g/d by the control steers ( $P < 0.001$ ). The total fasted and unfasted LWG of treated steers was improved by 29.6 kg (20.5%) or 36.3 kg (25%), respectively, over the untreated steers. There were no significant ( $P > 0.05$ ) differences in the amount of herbage eaten between treated and untreated group (7.4 vs 7.1 kg DM/hd/day, respectively). Feed conversion efficiency in the implanted group was improved by 15.7% over the untreated steers. The *in vitro* OMD of the herbage was 71% in both intake periods. Grazing behaviour, hormone and metabolite concentrations between treated and untreated steers were not significantly different ( $P > 0.05$ ). Net profit was increased in \$55 per implanted animal. In conclusion Compudose® proved to be a useful tool to increase steer performance and productivity under New Zealand pastoral conditions.

## **INTRODUCTION**

New Zealand beef steers are seldom grown to their potential on pasture, as maximising per animal performance usually does not result in maximum financial returns. Furthermore, the pattern of herbage growth and animal management associated with maximising whole-farm profitability often results in underfed animals. Efficient conversion of pasture to beef is nevertheless a key ingredient of profitable beef cattle finishing (Parker 1994).

Factors affecting the biological efficiency of meat production in beef steers are growth rate, mature weight and composition of growth. Of these, growth rate is the one that can be most easily controlled through farm management (Morris 1994).

The use of growth promoters, as a management tool to exert a positive effect on the efficiency of protein deposition in beef cattle, has been widely demonstrated (Heitzman 1976; McKenzie 1981; Buttery 1985; Unruh 1986; Bass 1989; Apple et al. 1991). These products have been used for over 30 years and can be classified into two broad groups, feed additives and anabolic implants. It has been estimated that in the order of 150 million implants are used annually in the world (Simpson & Moore 1990).

Growth promoters improve growth rate and feed efficiency through systemic action on the hormonal, biochemical or metabolic processes of the animal, resulting in more efficient deposition of protein and a reduction in the relative proportion of carcass fat (VanderWal 1976; Verbeke et al. 1976; Muir et al. 1977; Schanbacher 1984; Paterson & Salter 1985; Blackman 1990).

Hormones currently used as growth promotants are the naturally occurring oestrogenic, progestagenic and androgenic steroids, and synthetic compounds with similar action (xenobiotics). They have been used individually or in combination, selection of the appropriate combination usually being determined by the sex and age of the animal. Oestrogenic compounds are effective in stimulating liveweight gains and improving feed efficiency of growing and finishing ruminants. Research

under feedlot conditions has found that liveweight gain and feed conversion are improved 14 to 17% and 10 to 12%, respectively, resulting in heavier carcasses containing more protein, more moisture and less fat (Trenkle 1976; Heitzman et al. 1984; Roche & Quirke 1992).

Growth promotants, especially Compudose® (an oestrogenic growth promotant), have been used under pasture conditions in New Zealand for a number of years and proportional liveweight responses have been similar to those obtained from overseas feedlot-based research (McKenzie 1981, 1983; Bass 1989). However, there is no information available on feed intake and hence efficiency of liveweight gain under pastoral conditions.

Therefore, the objective of this study was to compare, under pasture feeding conditions, Compudose®-treated versus untreated steers in terms of liveweight gain, herbage intake, ingestive behaviour and circulating hormone and metabolite concentrations in the blood.

## **MATERIALS AND METHODS**

### **Animals and treatments**

Twenty 14-month-old Friesian steers ( $287.9 \pm 6.6$  kg (mean  $\pm$ SE) live weight (LW)), and sixteen 14-month-old Angus x (Hereford x Friesian) [A x (H x F)] steers ( $300.7 \pm 7.2$  kg) were used in the experiment which was conducted at the Massey University Animal Research Unit from 28 October 1992 (day 0 of trial) until 19 May 1993 (day 203 of trial).

The steers were randomly assigned within "breed" to either of two treatments: Compudose® (24 mg of oestradiol 17- $\beta$  impregnated in silicone rubber with an active life of 200 days; Elanco Products, South Auckland, New Zealand), inserted



subcutaneously in the middle third of the ear; or no Compudose controls. Unfasted liveweights of the steers were recorded on days -1, 33, 54, 86, 103, 149, 167, 184 and 202 of the trial, while 16 h fasted liveweights of the steers were recorded on days 0, 34, 55, 168, 185 and 203 of the trial.

## Pastures

The steers were grazed on pasture, the objective being ad libitum feeding conditions within the constraints of normal seasonal (spring, summer and autumn) herbage growth fluctuations. The main plant species in the pasture were ryegrass (Lolium perenne) and white clover (Trifolium repens).

Herbage intake was measured on two occasions during the trial (days 34-50 and days 168-184). During this time the steers were rotationally stocked around two paddocks. Pasture height was measured using the Hill Farming Research Organization (HFRO) sward stick (60 readings per paddock)(Barthram 1986) and the Ellinbank rising plate meter (50 readings per paddock)(Earle & McGowan 1979).

Herbage mass (Kg DM/ha) was also estimated in the first and second intake periods by cutting eight (0.18 m<sup>2</sup>) and twelve (0.09 m<sup>2</sup>) quadrats, respectively, to ground level using an electric shearing handpiece. The quadrat samples, randomly selected throughout the experimental paddocks, were taken at the beginning and the end of each intake period, on days 37 (pre-grazing) and 51 (post-grazing) for the first period and days 171 (pre-grazing) and 185 (post-grazing) for the second. Herbage samples were washed to remove soil contamination and dried at 100 °C to constant weight to determine herbage mass.

A sample of herbage was cut adjacent to each quadrat, bulked within each replicate and then subsampled to determine pre- and post-grazing pasture composition (i.e. the proportion by dry weight of grass leaf, grass stem, clover leaf, clover stolon, weeds and dead material), using the method described by the Ministry of Agriculture and Fisheries (1975).

## Herbage intake

Intraruminal chromium (Cr) controlled release capsules (CRC, Captec (NZ) Ltd, 4.06 cm core, 65% Cr<sub>2</sub>O<sub>3</sub>, multi-orifice end-plate) were used to estimate the faecal output of the steers (Morris et al. 1990; Parker et al. 1990ab). Six days from the day of administration were allowed for capsules to reach a steady rate of Cr<sub>2</sub>O<sub>3</sub> release in the rumen (Morris et al. 1990). Faecal samples were then collected during days 41-50 and days 175-184 for the first and second intake period, respectively.

Faecal samples (15-20 g wet weight) were obtained from each steer on at least 4 of the 5 sampling days per period by collecting faeces from the sward surface when steers were observed defaecating. Samples were collected into plastic pottles and oven-dried at 70 °C to a constant weight. A subsample of faeces from each day was bulked (within 5 day periods) on an equal dry weight basis (0.5-1.0 g/day) for each steer and ashed overnight at 550 °C (Parker et al. 1989). Replicates of the pooled faecal samples were then assayed to determine the Cr content of faeces by atomic absorption spectrophotometry (Costigan & Ellis 1987). The release rate of chromium oxide from the CRC (1172 mg Cr/day), and the recovery of Cr in the faeces (95%), were estimated based on previous studies carried out under similar conditions (Hirschberg et al. 1990, Nasution et al. 1991, Morris et al. 1993ab).

Hand-plucked samples (100-150 g wet weight/day) of herbage, similar to that consumed by the steers, were collected on days 40, 44, 47 and 49 for the first herbage intake period and days 176, 179, 182 and 185 for the second. Samples were immediately placed in crushed ice and stored at -12 °C until required for analysis. Subsamples (5-10 g) from the freeze-dried and ground (passed through a mesh of 1 mm) herbage samples were used to determine herbage digestibility by the *in vitro* method of Roughan & Holland (1977). Dry matter digestibility (DMD), organic matter digestibility (OMD), digestible organic matter in the dry matter (DOMD), and ash content of samples were determined.

The daily faecal output (FO; g/d dry matter (DM) or organic matter (OM)) was estimated by dividing the quantity of Cr released per day from the CRC by the

concentration of Cr (mg Cr/g DM or OM) in the faeces. Herbage intake (g OM/d) was determined by dividing FO by the in vitro indigestibility (1 -OMD) of the herbage. Metabolizable energy intake (MEI; MJME/d) was estimated as the product of 0.163 DOMD and DMI (Morris et al. 1993ab).

### **Ingestive behaviour**

Grazing behaviour was studied for two 24 h periods in each herbage intake period. Twelve steers (six per treatment) were observed in the first intake period and sixteen (eight per treatment) in the second. These animals were grazing in the same paddock, at the same stocking rate, but separated by electric fence in order to maintain them as a compact group. Ingestive activities recorded for each animal were grazing, ruminating, and idling times as defined by Hodgson (1982), and biting rate (i.e. the time taken for 20 bites). Grazing parameters were coded by letter once every 10 min for eight 6-hourly periods (0600-1200, 1200-1800, 1800-2400, 2400-0600), on consecutive days coinciding with the faecal sampling periods (Inwood et al. 1992).

### **Blood sampling**

Steers were blood sampled by tail venipuncture at 0900h on days -1, 49, 103, 149, and 202 of the trial. Blood samples (6ml) were withdrawn by vacutainers (Becton Dickinson Vacutainer Systems, Rutherford, New Jersey, USA) using EDTA as the anticoagulant, and the plasma was separated by centrifugation (2500 g for 20 min at 4 °C) and stored (at -20 °C) for subsequent analysis.

Plasma concentrations of growth hormone (GH) and insulin were determined using the homologous double-antibody radioimmunoassay (RIA) system described by Flux et al. (1984). The GH assay used bovine GH for iodination (USDA-bGH-I1, AFP-6500, 3.2 IU/mg, USDA Reproduction Laboratory, Beltsville Md.) and as standards (USDA-bGH-B1, AFP-5200, 1.9 IU/mg, USDA Reproduction Laboratory, Beltsville,

Md.) and had intra- and inter-assay coefficients of variation (CV) of 8.6% and 13.2%, respectively. The insulin RIA used bovine insulin (crystalline bovine insulin, Sigma Cat. No. I-5500, 23.4 IU/mg) for iodination and standards and had intra- and inter-assay CV of 8.2% and 12.4%.

Plasma metabolite assays were conducted using a Cobas Fara II autoanalyser (Hoffman-La Roche, Basel, Ltd, Switzerland). Metabolites measured, the methodology, and the intra- and inter-assay CV (respectively) were: glucose (Caraway 1976), 1.9% and 4.6%; urea (Tiffany et al. 1972), 2.1% and 3.4%; creatinine (Larson 1972), 1.0% and 1.4%; and non-esterified fatty acids (NEFA, McCutcheon & Bauman 1986), 2.4% and 8.6%

### **Statistical analysis**

Data on animal liveweights (fasted), herbage intakes, ingestive behaviour and plasma hormone/metabolite concentrations were subjected to analysis of variance at each sampling time to test the effects of Compudose® treatment. Pretreatment values (where available), were fitted in the statistical model as covariates. "Breed" [Friesian vs A x (H x F)] was also fitted but "breed" means and tests of differences are not reported as they were not the subject of an a priori hypothesis. All statistical analyses were conducted using the SAS computer package (SAS 1985) and the data are expressed as mean  $\pm$ SE.

## RESULTS

### Liveweight gain

The performance of control and Compudose®-treated steers is summarised in Table 2.1 and shown in Figure 2.1. Initial liveweight was not significantly different ( $P>0.05$ ) between the two groups. However, over the whole period, Compudose steers gained a mean 856 ( $\pm 17$ ) g/d compared with a gain of 710 ( $\pm 17$ ) g/d by control steers ( $P<0.001$ ). As a result, final liveweight was also significantly different ( $P<0.001$ ) between the two groups.

Table 2.1 Effect of Compudose® treatment for 203 days on liveweight (LW) and liveweight gain (LWG) of steers grazing ryegrass-white clover pastures (mean  $\pm$  SE).

	Control	Compudose®
No. of animals	18	18
Initial LW <sup>1</sup> (kg)	273.7 ( $\pm 4.8$ )	273.8 ( $\pm 4.8$ )
Final LW <sup>1</sup> (kg)	417.5 ( $\pm 3.4$ ) <sup>a</sup>	447.0 ( $\pm 3.4$ ) <sup>b</sup>
Daily LWG <sup>1</sup> (g/day)	710 ( $\pm 17$ ) <sup>a</sup>	856 ( $\pm 17$ ) <sup>b</sup>
Total LWG <sup>1</sup> (kg)	144.2 ( $\pm 3.4$ ) <sup>a</sup>	173.8 ( $\pm 3.4$ ) <sup>b</sup>

<sup>1</sup> Based on fasted liveweight (16 h off pasture), using initial liveweight as a covariate for subsequent weights.

<sup>ab</sup> Means with different superscripts are significantly different ( $P<0.05$ ).

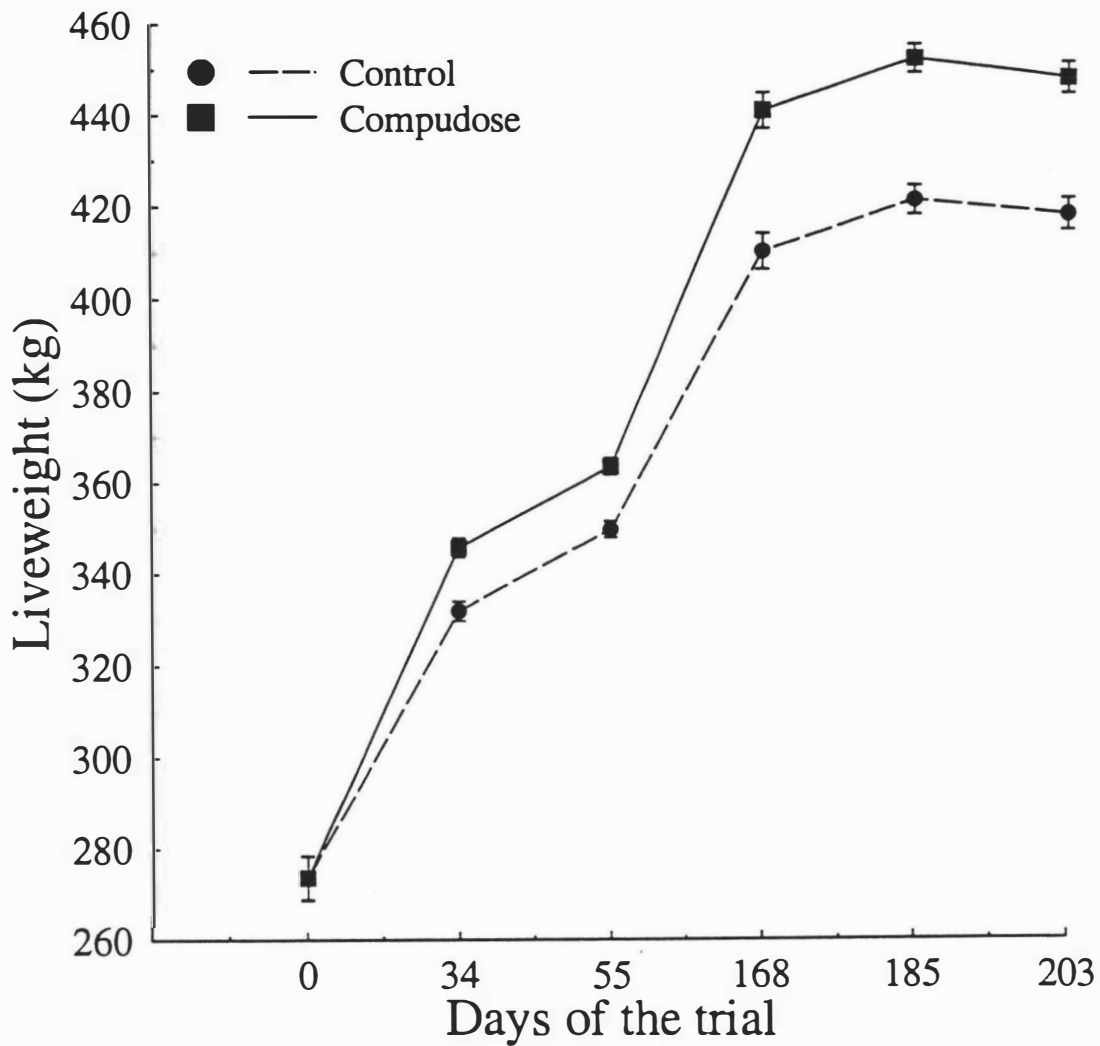


Figure 2.1 Effect of Compudose® ( - ■ - ) and no Compudose® ( --●-- ) treatment for 203 days on liveweight gain of steers grazing ryegrass-white clover pastures.

## **First Intake period**

### **Pasture characteristics**

Pasture characteristics during the first intake period are shown in Table 2.2. During December, steers grazed pastures with an average pre- and post-grazing herbage mass of 4361 and 4197 kg DM/ha, equivalent to sward heights of 20 and 15 cm as measured by sward stick, or 21 and 18 cm as measured by the rising plate meter, respectively.

Pastures contained 62% perennial ryegrass and 17% white clover before grazing; the corresponding values were 60% and 10% for pastures after grazing, respectively. Weeds and dead material of the pasture tended to increase from pre- to post-grazing, 3% to 8% and 18% to 22% respectively (Table 2.2).

The in vitro organic matter digestibility, dry matter digestibility, and organic matter digestibility of the dry matter, and ash content of hand-plucked herbage samples were 71, 68, 63, and 8.8 %, on a DM basis, respectively (Table 2.2).

### **Herbage intake and ingestive behaviour**

The growth performance of the steers in the first intake period (days 34-50 of the trial) is summarised in Table 2.3. Compudose®-treated steers had greater initial and final liveweights than control steers, but the average daily liveweight gain was not significantly different between the two groups over this period. Likewise, herbage consumption and ingestive behaviour were not influenced by Compudose® treatment.

Table 2.2 Herbage mass, sward height, botanical composition, in vitro digestibility, and ash content of herbage offered to the steers during December 1992 (first intake period, mean  $\pm$  SE).

	December Intake Period	
	Pre-grazing	Post-grazing
<b>Herbage mass (kg DM/ha)</b>	4361.0 ( $\pm$ 324)	4196.9 ( $\pm$ 334)
<b>Sward height (cm)</b>		
Sward surface height <sup>1</sup>	19.9 ( $\pm$ 1.2)	15.0 ( $\pm$ 1.2)
Compressed sward height <sup>2</sup>	21.2 ( $\pm$ 1.3)	18.1 ( $\pm$ 1.2)
<b>Botanical Composition<sup>3</sup></b>		
Perennial ryegrass		
leaf	0.25 ( $\pm$ 0.07)	0.19 ( $\pm$ 0.07)
stem	0.37 ( $\pm$ 0.04)	0.41 ( $\pm$ 0.04)
White clover		
leaf	0.14 ( $\pm$ 0.03)	0.06 ( $\pm$ 0.03)
stolon	0.03 ( $\pm$ 0.03)	0.04 ( $\pm$ 0.03)
Weeds	0.03 ( $\pm$ 0.03)	0.08 ( $\pm$ 0.03)
Dead material	0.18 ( $\pm$ 0.03)	0.22 ( $\pm$ 0.03)
<b><u>In vitro</u> digestibility<sup>3</sup></b>		
Organic matter digestibility		0.708 ( $\pm$ 0.27)
Dry matter digestibility		0.682 ( $\pm$ 0.24)
Organic matter digestibility of dry matter		0.626 ( $\pm$ 0.30)
<b>Ash Content<sup>3</sup></b>		0.088 ( $\pm$ 0.27)

<sup>1</sup> Measured by HFRO sward stick.

<sup>2</sup> Measured by rising plate meter.

<sup>3</sup> Expressed as a proportion of total DM.



Table 2.3 Effect of Compudose® on growth performance, herbage intake, and ingestive behaviour of steers grazing ryegrass-white clover pastures during the first intake period from 1 to 18 December 1992 (days 34-50 of the trial, mean  $\pm$  SE).

	Control	Compudose®
<b>Growth performance<sup>1</sup></b>		
No. of animals	18	18
Initial LW (kg)	331.89 ( $\pm$ 2.1) <sup>a</sup>	345.72 ( $\pm$ 2.1) <sup>b</sup>
Final LW (kg)	349.60 ( $\pm$ 1.8) <sup>a</sup>	363.26 ( $\pm$ 1.8) <sup>b</sup>
Daily LWG (g/day)	867 ( $\pm$ 121)	873 ( $\pm$ 121)
<b>Herbage intake</b>		
No. of animals	18	18
Organic matter intake (kg/head/day)	6.37 ( $\pm$ 0.25)	6.70 ( $\pm$ 0.24)
Dry matter intake (kg/head/day)	6.93 ( $\pm$ 0.27)	7.29 ( $\pm$ 0.26)
Digestible organic matter intake (kg/head/day)	4.34 ( $\pm$ 0.17)	4.57 ( $\pm$ 0.16)
Metabolisable energy intake (MJ/head/day)	70.76 ( $\pm$ 2.79)	74.44 ( $\pm$ 2.63)
<b>Ingestive behaviour</b>		
No. of animals	6	6
Bite rate (bites/min)	59.2 ( $\pm$ 3.1)	54.6 ( $\pm$ 3.1)
Grazing time (min/day)	513.2 ( $\pm$ 13.4)	526.4 ( $\pm$ 13.4)
Ruminating time (min/day)	600.1 ( $\pm$ 17.3)	576.8 ( $\pm$ 17.3)
Idling time (min/day)	326.3 ( $\pm$ 20.5)	339.9 ( $\pm$ 20.5)

<sup>1</sup> Based on fasted liveweight (16 h off pasture), using initial liveweight as covariate.

<sup>ab</sup> Means with different superscripts are significantly different ( $P < 0.05$ ).

## **Second intake period**

### **Pasture characteristics**

Pasture characteristics during the second intake period (days 168-184 of treatment) are shown in Table 2.4. During April steers grazed pastures with an average pre- and post-grazing herbage mass of 5568 and 4226 kg DM/ha equivalent to sward height of 14 and 9 cm as measured by sward stick, or 17 and 12 cm as measured by the rising plate meter.

Pastures contained 47% perennial ryegrass and 20% white clover before grazing; the corresponding values were 41% and 6% for pastures after grazing, respectively. Weed and dead material contents of the pasture tended to increase from pre- to post-grazing, 12% to 17% and 21% to 36% respectively (Table 2.4).

The *in vitro* organic matter digestibility, dry matter digestibility, organic matter digestibility of the dry matter, and ash content of hand-plucked herbage samples were 71, 68, 60 and 9.8 %, on a DM basis, respectively (Table 2.4).

### **Herbage intake and ingestive behaviour**

The growth performance of the steers in the second intake period is summarised in Table 2.5. In this second intake period three steers regurgitated their chromium capsule, and in another three the concentrations of chromium in faeces were very low. For these reasons the data from these animals were excluded from the analysis. Again, initial and final liveweight were greater in Compudose®-treated than in control steers but Compudose® had no effect on herbage intake or ingestive behaviour.

Table 2.4 Herbage mass, sward height, botanical composition, in vitro digestibility, and ash content of herbage offered to the steers during April 1933 (second intake period, mean  $\pm$  SE).

	April Intake Period	
	Pre-grazing	Post-grazing
<b>Herbage Mass (kg DM/ha)</b>	5567.7 ( $\pm$ 398)	4225.8 ( $\pm$ 372)
<b>Sward height (cm)</b>		
Sward surface height <sup>1</sup>	14.1 ( $\pm$ 0.5)	9.1 ( $\pm$ 0.5)
Compressed surface height <sup>2</sup>	16.5 ( $\pm$ 0.6)	11.8 ( $\pm$ 0.5)
<b>Botanical Composition<sup>3</sup></b>		
Perennial ryegrass		
leaf	0.32 ( $\pm$ 0.03)	0.20 ( $\pm$ 0.03)
stem	0.15 ( $\pm$ 0.02)	0.21 ( $\pm$ 0.02)
White clover		
leaf	0.12 ( $\pm$ 0.01)	0.05 ( $\pm$ 0.01)
stolon	0.08 ( $\pm$ 0.03)	0.01 ( $\pm$ 0.03)
Weeds	0.12 ( $\pm$ 0.06)	0.17 ( $\pm$ 0.06)
Dead material	0.21 ( $\pm$ 0.02)	0.36 ( $\pm$ 0.02)
<b><u>In vitro</u> digestibility<sup>3</sup></b>		
Organic matter digestibility		0.708 ( $\pm$ 0.17)
Dry matter digestibility		0.684 ( $\pm$ 0.16)
Organic matter digestibility of dry matter		0.595 ( $\pm$ 0.34)
<b>Ash Content<sup>3</sup></b>		0.098 ( $\pm$ 0.24)

<sup>1</sup> Measured by HFRO sward stick.

<sup>2</sup> Measured by rising plate meter.

<sup>3</sup> Expressed as a proportion of total DM.

Table 2.5 Effect of Compudose® on growth performance, herbage intake, and ingestive behaviour of steers grazing ryegrass-white clover pastures in the second intake period from 14 to 30 April 1993 (days 168-184 of the trial, mean  $\pm$  SE).

	Control	Compudose®
<b>Growth performance<sup>1</sup></b>		
No. of animals	15	15
Initial LW (kg)	407.18 ( $\pm$ 3.98) <sup>a</sup>	437.73 ( $\pm$ 3.98) <sup>b</sup>
Final LW (kg)	417.42 ( $\pm$ 3.50) <sup>a</sup>	450.63 ( $\pm$ 3.50) <sup>b</sup>
Daily LWG (g/day)	603 ( $\pm$ 149)	759 ( $\pm$ 149)
<b>Herbage intake</b>		
No. of animals	15	15
Organic matter intake (kg/day)	6.63 ( $\pm$ 0.28)	6.91 ( $\pm$ 0.26)
Dry matter intake (kg/day)	7.28 ( $\pm$ 0.30)	7.59 ( $\pm$ 0.29)
Digestible organic matter intake (kg/day)	4.30 ( $\pm$ 0.18)	4.48 ( $\pm$ 0.17)
Metabolisable energy intake (MJ/day)	70.06 ( $\pm$ 2.92)	72.96 ( $\pm$ 2.76)
<b>Ingestive behaviour</b>		
No. of animals	8	8
Bite rate (bites/min)	57.68 ( $\pm$ 2.84)	59.12 ( $\pm$ 2.84)
Grazing time (min/day)	475.5 ( $\pm$ 12.4)	503.6 ( $\pm$ 12.4)
Ruminating time (min/day)	495.4 ( $\pm$ 15.5)	459.2 ( $\pm$ 15.5)
Idling time (min/day)	469.1 ( $\pm$ 14.7)	476.0 ( $\pm$ 14.7)

<sup>1</sup> Based on fasted liveweight (16 h off pasture), using initial liveweight as covariate.

<sup>ab</sup> Means with different superscripts are significantly different ( $P < 0.05$ ).

## **Plasma hormone and metabolite concentrations**

The effect of Compudose® treatment for 203 days on circulating hormone and metabolite concentrations of the steers is summarised in Table 2.6 and shown in Figure 2.2. There were no significant differences between control and Compudose®-treated steers in growth hormone and insulin concentrations, except for the insulin concentration on day 202, which was greater in Compudose®-treated than in control steers. Plasma glucose, urea, creatinine, and NEFA concentrations were not significantly different between Compudose®-treated and untreated steers.

Table 2.6 Effect of Compudose® treatment for 203 days on circulating hormone and metabolite concentrations in steers grazing ryegrass-white clover pastures (mean ± SE).

Hormone/ metabolite	Day of Compudose® treatment <sup>1</sup>			
	49	103	149	202
<b>Growth hormone (ng/ml)</b>				
Control	20.7 (±3.1)	8.8 (±2.5)	8.3 (±2.1)	12.6 (±2.8)
Compudose®	20.4 (±3.1)	12.5 (±2.5)	14.0 (±2.1)	10.2 (±2.8)
<b>Insulin (pg/ml)</b>				
Control	835 (±136)	900 (±119)	904 (±120)	1037 <sup>a</sup> (±196)
Compudose®	961 (±136)	889 (±119)	1126 (±120)	1632 <sup>b</sup> (±195)
<b>Glucose (mM)</b>				
Control	4.4 (±0.1)	4.2 (±0.1)	4.0 (±0.0)	4.2 (±0.1)
Compudose®	4.4 (±0.1)	4.2 (±0.1)	4.1 (±0.0)	4.2 (±0.1)
<b>Urea (mM)</b>				
Control	4.7 (±0.1)	4.1 (±0.1)	6.2 (±0.1)	8.3 (±0.2)
Compudose®	5.0 (±0.1)	4.1 (±0.1)	6.4 (±0.1)	8.4 (±0.2)
<b>Creatinine (mM)</b>				
Control	0.097 (±0.003)	0.092 (±0.002)	0.102 (±0.002)	0.108 (±0.003)
Compudose®	0.097 (±0.003)	0.091 (±0.002)	0.102 (±0.002)	0.104 (±0.003)
<b>NEFA (mEq/ml)</b>				
Control	0.146 (±0.012)	0.086 (±0.007)	0.126 (±0.009)	0.092 (±0.008)
Compudose®	0.122 (±0.012)	0.097 (±0.007)	0.131 (±0.009)	0.086 (±0.008)

<sup>1</sup> Values are covariate adjusted for day -1 values.

<sup>ab</sup> Means within columns and hormone/metabolite with different superscripts are significantly different (P<0.05).

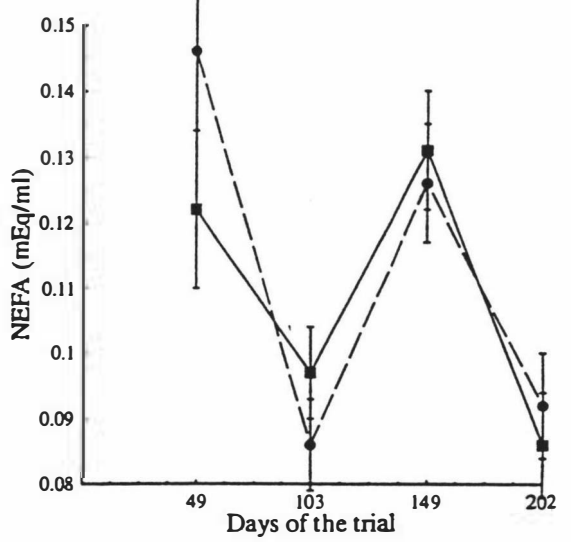
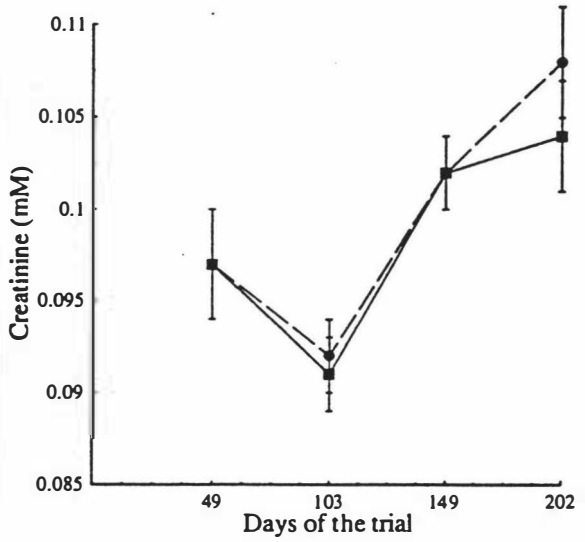
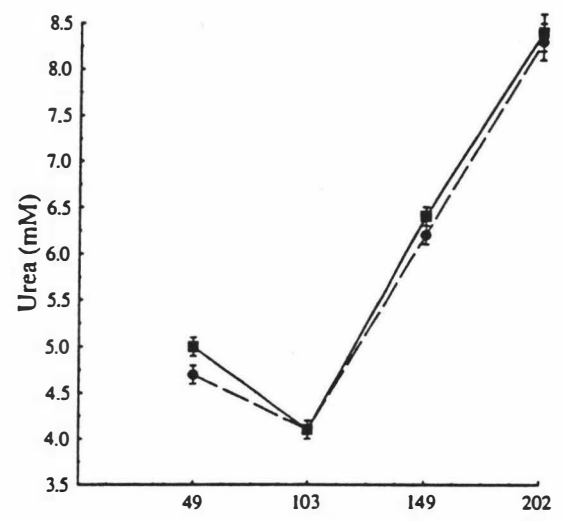
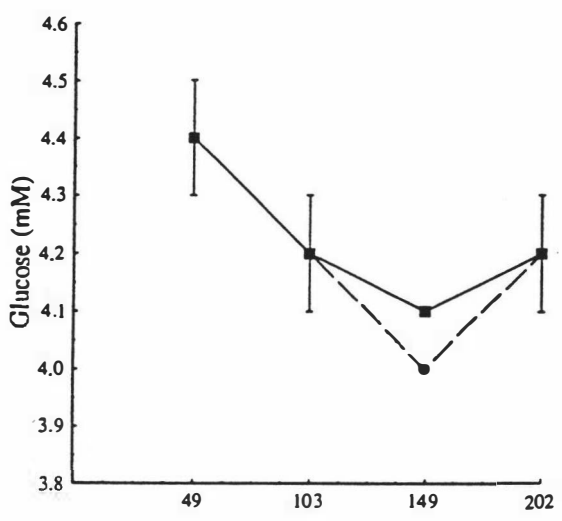
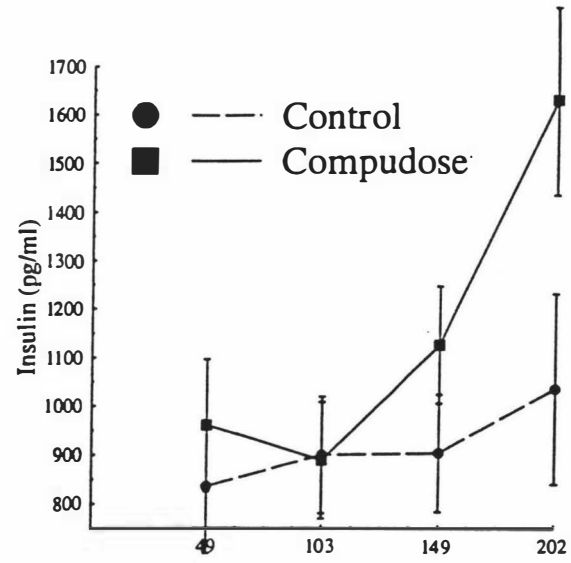
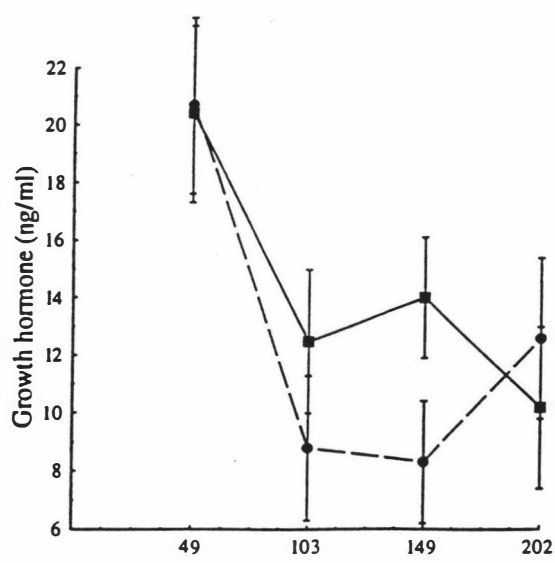


Figure 2.2 Effect of Compudose® (—■—) and no Compudose® (—●—) treatment for 203 days on liveweight gain of steers grazing ryegrass-white clover pastures.

## **DISCUSSION**

### **The effect of Compudose® in finishing steers at pasture**

The present experiment was designed to evaluate the effect of Compudose® (oestradiol-17 $\beta$ ) on liveweight gain, herbage intake, grazing behaviour and circulating hormone and metabolite concentrations in growing steers grazing ryegrass-white clover pastures from late spring until late autumn.

Throughout the 203 days of the trial the advantage in total liveweight gain for Compudose®-treated steers was 29.6 kg (unfasted liveweight) per animal, and the advantage in average daily gain was 865 versus 710 g/hd/day in treated and untreated steers, respectively. This equates to an improved in liveweight gain in implanted steers of 21.8 % over that of control steers. The magnitude of the response in liveweight gain for the Compudose®-treated steers agrees with research results using Compudose® on feedlots (Roche & Quirke 1986; O'Callaghan 1988 et al; Fiems et al. 1991) and for those obtained under European and North America grazing conditions (Shorrocks et al. 1978; Rumsey 1990), and in New Zealand (McKenzie 1981, 1983; Bass 1989).

One of the main objectives in beef cattle farming is to increase the level of production and/or productivity (i.e. to elevate the number of animals finished per unit of area or to obtain heavier animals using the same area). However, an increase in the number of animals per unit of land increases the efficiency of pasture utilisation but at the expense of liveweight gain per animal. Therefore, a higher stocking rate will require more time and/or supplements to reach the final target liveweight (McCall & Marshall 1991; Morris 1994; Parker 1994).

Conversely, increases in animal performance obtained through increases in herbage allowance per animal often result in low pasture utilisation, and a subsequent reduction in sward density and herbage quality (Hodgson 1985).



In practice a compromise usually exists between increasing per head and per hectare production. Furthermore, the efficiency with which the animals convert feed into meat complicates this relationship (Ketelaars & Tolkamp 1992).

Therefore, to evaluate the efficiency of production in implanted and non-implanted steers under grazing conditions, herbage intake of these animals was estimated on two occasions during the trial. It is clear that continuous and direct herbage intake measurement in animals is highly desirable in order to estimate feed conversion efficiency and efficiency of production. However, under grazing conditions this is impractical and extremely expensive. Furthermore, the accuracy achieved by indirect herbage intake methods such as chromic oxide means that they provide a satisfactory estimate of herbage intake in grazing animals (Parker et al. 1990ab). Therefore, herbage intake estimates were made one month after and one month before the experiment had started and finished, respectively.

Dry matter intake (DMI) and organic matter intake (OMI) tended to be slightly higher for the treated group during the first period. However, if consumption of DMI or OMI was expressed on a per 100 kg liveweight basis, the difference between the two groups disappeared. Consequently, the slight difference in herbage intake between groups was a result of differences in live weight at the time of herbage intake measurement, rather than of treatment per se (Table 2.7).

A similar scenario existed in the second intake period when implanted steers tended to eat slightly more than control steers. However, when intake was converted to DMI or OMI per 100 kg of liveweight these differences disappeared (Table 2.7).

During the first intake period, Compudose®-treated steers were slightly less efficient in feed conversion ratio than control steers (i.e. the implanted steers needed 6% more feed to gain the same amount of liveweight than control steers). In the second period, the feed conversion efficiency decreased in both groups (19% in Compudose®-treated and 54% in controls). However, now the implanted group appeared to be more efficient in converting herbage to liveweight, because they needed less feed per unit of liveweight gain (10.0 vs 12.2 kg DM/kg LW,

respectively)(Table 2.7). However, these results could potentially be misleading because they rely in measurements of liveweight change which were made over a short time period and were not consistent with those from the whole trial.

Furthermore, results from the ingestive behaviour measurements confirmed the herbage intake measurements. Thus, treated and untreated steers in the first intake period expended slightly more time ruminating, a reflection of their greater herbage intakes, and less time idling. In the second period both groups increased the time spent idling and decreased the ruminating period. Grazing time was very similar in implanted and non-implanted steers throughout both periods of intake measurement. The grazing behaviour measurements corresponded with those reported by Hodgson (1982, 1985) for cattle and for those found in New Zealand for bulls (Morris et al. 1993b) and beef heifers (Khadem et al. 1993) grazing ryegrass-white clover pastures.

In order to evaluate the effect of Compudose® implants on the production efficiency of steers under grazing conditions, the data from the two intake measurement periods were extrapolated over the entire trial (Table 2.7). This requires some assumptions, namely:

- a) The herbage intake for each group of steers throughout the trial was taken as the average herbage DMI or OMI intake of the steers measured during the first and second intake periods.
- b) Steers grazed different paddocks outside the two herbage intake periods. Consequently, it had to be assumed that pasture quality conditions in both intake periods were representative of the herbage eaten by the steers throughout the entire period.

Compudose®-treated steers gained more liveweight, consumed more herbage DM and converted feed into meat more efficiently than control group steers (8.64 vs 10.0 kg DM/kg LW, respectively). Compudose®-treated steers, therefore, had

Table 2.7 The effect of Compudose® on efficiency of production of steers grazing ryegrass-white clover pastures.

	Control	Compudose®
<b>First intake period</b>		
Average LW (kg)	340.8	354.5
ADLWG <sup>1</sup> (g/hd/day)	870	870
DMI (kg/hd/day)	6.9	7.3
DMI/100 kg LW (kg/100 kg LW/day)	2.02	2.06
OMI (kg/hd/day)	6.4	6.7
OMI/100 kg LW (kg/100 kg LW/day)	1.9	1.9
Feed conversion <sup>2</sup>	7.93	8.39
Efficiency <sup>3</sup>	0.13	0.12
<b>Second intake period</b>		
Average LW (kg)	412.3	444.2
ADLWG <sup>1</sup> (g/hd/day)	600	760
DMI (kg/hd/day)	7.3	7.6
DMI/100 kg LW (kg/100 kg LW/day)	1.8	1.7
OMI (kg/hd/day)	6.6	6.9
OMI/100 kg LW (kg/100 kg LW/day)	1.6	1.6
Feed conversion <sup>2</sup>	12.2	10.0
Efficiency <sup>3</sup>	0.08	0.10
<b>Whole trial</b>		
Total LWG (kg)	144.2	173.8
ADLWG <sup>1</sup> (g/hd/day)	710	865
Total DMI (kg)	1441.3	1502.2
Feed Conversion <sup>2</sup>	10.0	8.64
Efficiency <sup>3</sup>	0.10	0.11

<sup>1</sup> ADLWG = average daily liveweight gain.

<sup>2</sup> Feed conversion = DMI (kg/hd/day) / LWG (g/hd/day).

<sup>3</sup> Efficiency = LWG (g/hd/day) / DMI (kg/hd/day) x 100.

improved liveweight gains by 21.5% and feed conversion ratios by 15.7%, in comparison with untreated steers (Table 2.7). The difference between results of this analysis, and that conducted over the individual intake periods, reflected the fact that Compudose® increased liveweight gain over the whole trial but not over the relatively short intake periods.

Growth promoters, tend to modify the endocrine system, altering the nutrient partitioning process and thereby changing the relative rates at which tissues are synthesised. Oestrogenic implants, like Compudose®, seem to act indirectly on tissues changing the concentrations of other endogenous anabolic and catabolic hormones e.g. growth hormone, insulin, thyroxine, etc. (Schanbacher 1984). In order to explain the advantages of efficiency of liveweight gain and feed conversion of implanted steers with respect to non-implanted steers, blood samples from the treated and untreated steers were taken at intervals of approximately fifty days to determine concentrations in plasma of growth hormone, insulin, glucose, urea, creatinine and non-esterified fatty acids (NEFA).

In general, circulating plasma concentrations of hormones (growth hormone and insulin), and metabolites (glucose, urea, creatinine and NEFA) were not significantly different between treated and untreated steers. However, the levels of hormones and metabolites tended to be elevated in the Compudose group than in control group, with the exception of creatinine and NEFA (Figure 2.2).

It is possible that these small differences in hormone and metabolite concentrations in the Compudose®-treated steers were sufficient to stimulate improved growth rate and feed conversion efficiency throughout the trial. However, the results of this component of the study tell us little about the mechanism by which Compudose® exerts its effects.

## Economic analysis

As has been pointed out by Parker (1977), the increment in liveweight gain or in meat output per unit of land is not always in a particular farmer interest as the farmer is usually concerned with maximising net income. Additionally, profit from livestock production is directly affected by daily liveweight gain, cost of gain, and feed conversion efficiency (Schanbacher 1984).

In order to calculate the economic benefits from using Compudose® implants under New Zealand pastoral systems the following procedure was carried out:

Currently, Compudose-200<sup>R</sup> costs \$ 8.17 (including GST) per implant. Assuming an average liveweight price for steers of \$1.00/kg (McDonald 1995, pers.comm.), and a total liveweight (unfasted liveweight, as this is the usual form in which stock are sold from the farm) response of 36.3 kg from Compudose® treatment then this translates to a gross return of \$36.30 and net profit of \$28.13 per treated animal. In investment terms, this represents a return of \$3.44 for every dollar invested.

Furthermore, carcass dressing out percentage usually increases with increases in animals liveweight (eg. 50% and 51% for 440 and 480 kg liveweight steers, respectively; Outlook 1995) and, at the same time, there is an increment in price per kg of carcass weight (e.g. \$1.75 and \$1.84 per kg of carcass weight for 440 and 480 kg liveweight steers, respectively, Outlook 1995). Taking the above into consideration, the net benefit that farmers can obtain from implanted heavier steers is \$67.00 (i.e. \$362.00 vs \$429.00 for 440 and 480 kg of LW steers, respectively, Outlook 1995)(Table 2.8).

Therefore, the net profit from using Compudose® implants in finishing steers under grazing conditions in New Zealand would be around **\$55.00 per implanted steer** (i.e. \$67.00 for the extra liveweight gain and heavier weights range of steers less \$8.17 for the implant cost and the charge made by some processing works of up to \$4 per implanted steer processed (Forgie 1995))(Table 2.8).

Table 2.8 Net profit from using Compudose® implants in finishing steers at pasture under New Zealand conditions.

	Control steers	Compudose® steers
Total unfasted LW (kg)	439.08 (440.00)	475.34 (480.00)
Price per kg of carcass weight	\$1.75	\$1.84
Price per carcass	\$362.00	\$429.00
Net profit for heavier animals		\$67.00/steer
Cost of Compudose® implant	-	\$8.17
Extra processing charge	-	\$4.00
Net income for using Compudose® 200	-	\$55.00/steer

This increased income using of Compudose® implants was achieved at a similar feed intake between treated and control steers (aside from the slightly greater feed intake of treated steers due to their being heavier at any particular time). Therefore the increase in income is primarily a result not of increased intake but of a more efficient feed utilisation.

## CONCLUSIONS

New Zealand is one of the few countries in the world that bases its economy on agricultural production systems. In particular, beef cattle production plays a significant role through the quantity and quality of exported products. However, the potential of beef production could still be increased by using appropriate technology.

Hormonal growth implants have been proven to increase animal performance primarily under feedlot conditions. However, the literature available with regard to their use in pasture-based systems is very limited. Therefore, this trial was conducted to generate information about the effects of Compudose® in beef cattle production under grazing conditions. The main points that emerged from this study were as follows:

- 1) Compudose® implants (oestradiol-17 $\beta$ ) increased by 20.5% (29.6 kg) and 25% (36.3 kg) the total fasted and unfasted liveweight gain in steers grazing ryegrass-white clover pastures from late spring to late autumn.
- 2) Grazing behaviour of steers was not modified by the use of Compudose® implants.
- 3) The amount of herbage eaten by implanted steers was not significantly different from that eaten from non-implanted steers. As a consequence, treated steers converted herbage into liveweight 15.7% more efficiently than non-implanted steers.
- 4) Circulating hormone and metabolite concentrations of the Compudose-implanted and non-implanted steers were virtually the same throughout the entire period. However, there was a slight tendency for implanted steers to have higher growth hormone and insulin concentrations than in non-implanted steers.

- 5) Economic analysis showed that the use of Compudose® implants in finishing steers at pasture increased net income by \$55.00 per implanted steer.

In conclusion the use of Compudose® implants in finishing steers is a useful management tool to increase animal performance and productivity under New Zealand pastoral conditions.



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