

**THE EFFECT OF SUPPLEMENTARY LIGHT ON THE
PRODUCTIVE PERFORMANCE OF DORPER LAMBS FED
INTENSIVELY**

By

Pieter Johannes Andreas Vos

Thesis submitted in fulfillment of the requirements for the degree

**Magister Technologiae:
Agriculture**

at the

**School of Agriculture and Environmental Sciences
Faculty of Health and Environmental Sciences**

of the

**CENTRAL UNIVERSITY OF TECHNOLOGY,
FREE STATE**

Supervisor: Prof P.J. Fourie (D. Tech)

Co-supervisor: Prof S.S. Abiola (Ph.D)

BLOEMFONTEIN

January 2010

TABLE OF CONTENTS

	Page
ABSTRACT	v
OPSOMMING	vi
PREFACE	vii
LIST OF ABBREVIATIONS	ix
LIST OF FIGURES	xi
LIST OF TABLES	xi
CHAPTER 1	
GENERAL INTRODUCTION	
1.1 Introduction	1
1.2 Overview and background	1
1.3 Rational	3
1.4 Objectives of the study	5
1.5 Project Hypotheses	5
1.6 References	6
CHAPTER 2	
LITERATURE OVERVIEW	
2.1 Introduction	8
2.2 Feedlot economics	9
2.3 History of the Dorper	9
2.4 Feed for maintenance, Feed conversion ratio (FCR) and average daily gain (ADG)	11
2.4.1 Genetic selection	12

2.5 Body measurements	13
2.5.1 The application of body measurements	13
2.5.2 Heritability of body measurements	15
2.6 Ultrasound	15
2.6.1 Background	15
2.6.2 Plasma leptin versus ultrasound fat thickness determination	16
2.6.3 Procedure for using ultrasound	17
2.6.4 Application of ultrasound	18
2.7 Supplement light (SL)	19
2.7.1 Introduction	19
2.7.2 The effect of supplement light on different species	21
2.7.2.1 Dairy cattle	21
2.7.2.2 Beef cattle	23
2.7.2.3 Poultry	24
2.7.2.4 Pigs	24
2.7.2.5 Sheep	26
2.7.3 Photoperiod and hormone secretion	28
2.7.4 Photoperiod and reproduction in sheep	30
2.7.5 Photoperiod and temperature	31
2.8 References	33

CHAPTER 3

MATERIALS AND METHODS

3.1 Study site	40
3.2 Animals	40

3.3 The feeding regime	41
3.4 Facilities	42
3.5 Ultrasound measurements	43
3.6 Slaughter of Animals	43
3.7 Performance data	44
3.8 The Processing of data	45
3.9 References	46
CHAPTER 4	
RESULTS AND DISCUSSION	
4.1 Introduction	48
4.2 Growth parameters	48
4.3 A comparison of wethers and male lambs with regard to growth parameters	52
4.4 Carcass parameters	55
4.5 Body measurements	57
4.6 Hair type vs. wool type Dorper sheep	58
4.7 References	60
CHAPTER 5	
5.1 GENERAL CONCLUSION AND RECOMMENDATION	63
ADDENDUM A	66

THE EFFECT OF SUPPLEMENTARY LIGHT ON THE PRODUCTIVE PERFORMANCE OF DORPER LAMBS FED INTENSIVELY

ABSTRACT

The objective of this research study was to quantify the differences in average daily gain (ADG), back fat thickness (BFT), eye muscle area (EMA), fat thickness (FT) on different body parts, the feed conversion ratio (FCR) and body dimensions (by means of body measurements) of Dorper lambs exposed to supplemented light. For this study 120 Dorper lambs (115 ± 10 days old) weighing (29.76 ± 5.01 kg) were used. The lambs were randomly divided into three homogeneous groups (20 castrated and 20 intact males). The three groups were then exposed to different levels of supplemented light at 145 lux (16h, 24h and normal photoperiod). The animals were fed ad libitum with pellets containing 9.5 MJ ME/kg DM and 12% CP in open pens. The animals were weighed every 7 days while ultrasound scanning of the EMA and the BFT was done at the beginning and the end of the 35 day trial. The ADG, FCR and feed intake (FI) were calculated at the end of the trial. Linear body measurements including shoulder height, body length and heart girth were taken at day 1 and day 35 respectively. All the animals were slaughtered at the end of the trail. The carcasses were then weighed, graded and the FT was measured with a caliper. The final results of the study showed that no significant differences between the three treatment groups (consisting of wethers and rams) in terms of body measurements, ultrasound scanning ADG and FCR could be detected. However, a significant difference was found between the wethers and the rams in the whole trial for ADG. The ADG of the rams exposed to 16 hours of supplemented light was significantly better than the normal photoperiod and the 24 hour light supplementation group.

DIE EFFEK VAN AANVULLENDE LIG OP PRODUKSIEPARAMETERS VAN DORPER LAMMERS ONDER INTENSIEWE TOESTANDE

OPSOMMING

Die doel van hierdie navorsingstudie was om die verskille in gemiddelde daaglikse toename (GDT), rugvetdikte, oogspieroppervlakte, vetdikte op verskillende liggaamsdele, voeromsetverhoudig (VOV) en liggaamsdimensies (deur middel van liggaamsmates) van Dorper lammers wat blootgestel is aan verskillende vlakke van liganvulling te ondersoek. Vir hierdie studie is 120 Dorper lammers (115 ± 10 dae oud) met 'n gemiddelde gewig van (29.76 ± 5.01kg) gebruik. Die lammers is ewekansig in drie homogene groepe verdeel (20 hamels en 20 ramlammers). Die drie groepe is blootgestel aan verskillende vlakke van aanvullende lig teen 145 lux (16h, 24h en normale fotoperiode). Die diere is *ad libitum* in oop krale met voerpille wat 9.5 MJ ME/kg DM en 12% CP bevat het, gevoer. Die diere is elke 7 dae geweeg terwyl ultrasoniese skandering van die oogspieroppervlak en rugvetdikte aan die begin en einde van die 35 dae proef gedoen is. Die GDT, VOV en voerinname (VI) is aan die einde van die proef bereken. Liniêre liggaamsmates, insluitende skouerhoogte, liggaamslengte en borsomtrek van die diere is respektiewelik op dag 1 en dag 35 van die proef geneem. Al die diere is aan die einde van die proef geslag. Die karkasse is geweeg, gegradeer en die vetdikte is met behulp van 'n diktepasser ("caliper") gemeet. Die finale resultate van die studie dui daarop dat geen betekenisvolle verskille tussen die drie verskillende groepe (bestaande uit hamels en ramme) van liganvulling in terme van liggaamsmates, ultrasoniese skanderings, GDT, en VOV waargeneem is nie. 'n Betekenisvolle verskil is wel gevind in die GDT tussen ramme en hamels oor die totale proef. Die GDT van die ramme wat aan 16 uur liganvulling blootgestel was was betekenisvol beter as die van die normale fotoperiode en 24 uur liganvulling groep.

PREFACE

The aim of this study was to quantify the differences in average daily gain (ADG), back fat thickness (BFT), eye muscle area (EMA), fat thickness (FT) on different body parts, the feed conversion ratio (FCR), body dimensions (by means of body measurements) and the weight of internal organs of Dorper lambs exposed to supplemented light in a feedlot.

This study includes a general introduction which focuses on the background, the objectives and hypothesis of this study; the literature overview; materials and methods; results of the effect of supplement light on the ADG and FCR of Dorper lambs under intensive conditions in a feedlot and the conclusions.

I wish to express my sincere gratitude to the following:

Professor Pieter Fourie who initiated this study. His enthusiasm, guidance, encouragement and dedication to this study were highly appreciated.

The National Research Foundation and the Central University of Technology, Free State, for the financial support.

Dr Jan Vos for making available the facilities and 120 Dorper lambs for this study.

Mr Cyril Stannard from Grootfontein Agricultural College for his help with the ultrasonic scanning.

Dr Andre Van Zyl from the Free State University for the statistical analysis.

Mr Dawid Snyman, health inspector of Werda Abattoir and Mr Dirk Zannenbergh of SAMMIC for the slaughtering of the animals and taking of the carcass measurements.

My parents, family and friends for their help, guidance and moral support during the study.

Above all, to God who gave me the opportunity and ability to complete this study.

I hereby declare that this thesis, submitted for the degree Magister Technologiae, is my own original work and has not been submitted by me or anyone else in respect of any qualification to any other institution.

P.J.A. VOS

LIST OF ABBREVIATIONS

ADG	-	Average daily gain
AT	-	Adipose tissue
BFT	-	Back fat thickness
BH	-	Body height
BL	-	Body length
BW	-	Body weight
C	-	Celsius
cm	-	Centimeter
D	-	Dark
EMA	-	Eye muscle area
EP	-	Extended Photoperiod
EPD	-	Expected progeny differences
FCR	-	Feed conversion ratio
g	-	Gram
h	-	Hour
kg	-	Kilogram
L D-area	-	Longissimus dorsi -area
L D	-	Long day
L	-	Light
MJ/kg	-	Mega Joule per kilogram
NP	-	Natural photoperiod
PRL	-	Prolactin
P8	-	Fat layers on the rump

- S D - Short day
- SL - Supplemented light
- WCW - Warm carcass weight

LIST OF FIGURES

	Page
Figure 3.1: Ultrasound images of the eye muscle area and fat thickness on the rump	43
Figure 3.2: Fat thickness on the rump	44
Figure 3.3: Fat thickness on the rib area	44
Figure 4.1: Growth curves of the three treatment groups	50

LIST OF TABLES

	Page
Table 4.1: The effect of supplemented light on BW, Final weight and Warm carcass weight (mean \pm S.E.) of Dorper lambs fed intensively	49
Table 4.2: The differences between ADG, Total weight gained (TWG), Rump fat gained (RFG), EMAG (gained), Heart girth gained (HGG)	52
Table 4.3: The effect of supplemented light on ADG (mean \pm S.E.) for different parameters	53
Table 4.4: The effect of supplemented light on certain carcass parameters of (mean \pm S.E.) of Dorper	

lambs measured in the abattoir 55

Table 4.5: The effect of supplemented light on certain body measurements (mean \pm S.E.) of Dorper lambs fed intensively 57

Table 4.6: The effect coat type on certain parameters (mean \pm S.E.) of Dorper lambs 59

CHAPTER 1

GENERAL INTRODUCTION

1.1 Introduction

Indications are that the future demand of mutton and lamb will probably exceed the supply specifically under extensive production systems. The question arises whether sheep feedlots should play a bigger role than they do at present? Intensive feeding involves any measures taken where animals are withdrawn from the veld and placed on a higher level of feeding; this even includes the strategic use of cultivated pastures (Louw & Read, 1991).

In South Africa sheep farmers were forced to look at the finishing of lambs in feedlots during the disaster drought in the early and mid 1980's in order to increase their income. At present there is a higher demand for red meat as the population of South Africa increases. Due to the limitation of agricultural land, horizontal expansion of production is impossible. Feedlot finishing of cattle gives a vertical opportunity to increase production in order to meet the supply and the need of the population.

1.2 Overview and background

The finishing of cattle in feedlots is an established enterprise in South Africa, however, the same cannot be said for sheep. One of the reasons could be that in years when the veld conditions are good, sheep farmers market their lambs at a later age directly from the veld. This creates the possibility of overuse and declining of natural pastures and a reduction of carrying capacity.

An important motivation in the extensive sheep farming areas of feedlot finishing is the fact that lambs are withdrawn at an early age from the available natural

pastures with the result that the reserve capacities were saved for the need of the production ewes. The adult ewe utilizes natural pastures more efficiently to maintain lambs for meat production. Lambs growth is highly efficient when a well balanced ration is used. When meat production is the main aim of farming, finishing of lambs in a feedlot should be a permanent part of the sheep management program (Veekos, 1988).

The intensive feeding and fattening of sheep are highly specialized practices which require high levels of management to ensure success. A sound knowledge of nutrition, diseases and market prices is essential for such an undertaking. In any intensive production system factors such as management, housing and feeding are of utmost importance (Louw & Read, 1991). Margins of feedlot operators are minimal. Any adverse management decisions during the feedlot operation are likely to be costly and result in negative returns of investment. Feeding is a major cost in feedlot operations (Bertram & Phillips, 2004).

The profitability of the feedlot is of utmost importance for the farmer. The financial results must be monitored as well as records about feed consumption, feed costs, weight gain and the prices of meat. The feed margin of a feedlot takes two biological changes into account during the finishing of lambs, namely the gain of body weight as well as the dressing percentage and compare it with the feed costs for the production of 1kg meat. The quality of meat (grading) could improve during finishing in a feedlot (Veekos, 1988).

The choice of the type of lamb as well as the choice of a specific diet (ration) will influence the end result dramatically. Diverse management includes the effective use of facilities, health control precautions and experienced supervision which are vital to the success of the enterprise (Veekos, 1988).

In South Africa thousands of Dorper lambs are finished in feedlots every year. The Dorper is the second largest sheep breed in South Africa and breeding stock

has also been exported to other countries (Terblanche, 1979). It is a synthetic, non-wooled, mutton breed, which was developed by crossing Dorset Horn rams and Blackhead Persian ewes (Nel, 1993). The fat-rumped Blackhead Persian ewes proved to be well adapted to harsh local conditions, while the Dorset Horn ram in contrast, was poorly adapted to harsh environments. However, through crossbreeding, the offspring inherited a sufficient complement of adapted genes to overcome most of these shortcomings. The Dorset Horn mainly contributed to the Dorper breed in terms of carcass conformation and fat distribution. In Dorper lambs the gain of 1kg bodyweight creates more than a 0,5kg carcass weight gain. The Dorper is therefore a medium maturing sheep that can be finished off in 30 days.

1.3 Rationale

Satisfactory progress was made over the past decades with regard to feeding technology, feedlot outlay and the identification of animals that performed well under feedlot conditions. A factor that may largely impact on the performance of animals under feedlot conditions in the near future, is light manipulation. Manipulation is in the form of photoperiod (the period of daily illumination an organism receives) management and is used by many dairy producers to increase profits (Maasz, 2006).

Light management is an important component of broiler management (Classen, 2000). Poultry producers use lighting to stimulate layers while sheep and horse breeders manipulate the breeding season with light exposure. Though cattle are not seasonal breeders, the photoperiod can affect their reproduction; for example, long days hasten puberty in heifers in comparison to relative natural day length (Dahl,2001;Hansen, 1985).

A study by Small *et al.* (2003) demonstrated that manipulation of the photoperiod influences the growth and reproductive function of cattle. Increased rate of gain

in heifers supplemented with 16L:8D was associated with greater consumption of feed, which commenced approximately eight weeks after initiation of 16L:8D photoperiods. Heifers given 16L:8D were more efficient in converting feed into weight gain (Peters *et al.*, 1980).

The photoperiod can exert a positive effect on dairy performance when managed properly. Long days have consistently been shown to improve milk yields during established lactation. In addition, photoperiod management can be used to improve heifer growth and maximize accretion of lean tissue, including mammary parenchyma (Dahl & Peticlerc, 2003).

Increasing daily light exposure from 8 to 16 hours increased average daily body weight gains of sheep and Holstein cattle. An increase in live weight gain of wethers or intact ewe lambs exposed to 16L:8D photoperiods as compared with animals exposed to 8L:16 D were reported (Tucker *et al.*, 1984). The effects of seasonal changes in day length on the reproduction in sheep are well-known, but in recent years it become apparent that improved growth rates and food intakes of sheep, cattle and deer were associated with longer day length (Forbes 1982).

Voluntary feed intake doubled in sheep in LD (long-day photoperiod) was compared with SD (short –day photoperiod) and this was associated with an increase in live weight (Marie *et al.*, 2001). Increased carcass weight without sacrifice of quality of yield is a distinct advantage of producing market lambs with the aid of artificial lighting (Schanbacher & Crouse 1980).

In a personal conversation with Human (2007), Livestock Manager of GWK Pty Ltd, 10% of all Dorper lambs and 80% of all Merino lambs are fed intensively in feedlots before slaughtering. The question that arose was whether light manipulation will affected the feedlot performance of Dorper lambs. The project attempted to improve the cost efficiency and economic viability of feedlots by improving feed intake and growth under conditions of increased exposure to light.

1.4 Objectives of the study

The objectives of this study are:

- to evaluate the differences in average daily gain (ADG), average feed intake, back fat thickness (BFT), eye muscle area (EMA), dressing percentage and feed conversion ratio (FCR) of animals exposed to different levels of light supplementation;
- to evaluate the economic implication of supplemented light on Dorper lambs fed intensively;
- to determine whether castration (using a burdizo) had any effect on the feedlot performance of animals subjected to supplementary light.
- to determine whether light supplementation had any effect on body dimensions.

1.5 Project Hypotheses

- The dry matter intake of lambs exposed to additional light will be higher than those lambs exposed to natural conditions.
- Light supplementation will have a positive effect on the ADG and FCR of the Dorper lambs.
- Light supplementation will have a positive effect on feedlot economics.

1.6 References

Bertram, J. & Phillips, A., 2004. Basic Guidelines for a Feetlot Operation. Anim. Prod. Alice, Springs. 1- 6.

Classen H.L., 2000 Barn of the future lighting programs. Ministry of Agriculture and food. 1-5.

Dahl, G.E. 2001. Photoperiod Management of Dairy Cattle. Ministry of Agriculture and Food. 1-6.

Dahl, G.E. & Peticlerc, D., 2003. Management of photoperiod in dairy herd for improved production and heath. J. Anim. Sci. 81:11-17.

Forbes. J.M., 1982. Effects of lighting pattern on growth, lactation and food intake of sheep, cattle and deer. Livestock Prod. Sci. 9:361-374.

Hansen, P.E., 1985. Seasonal modulation of puberty anestrus in cattle: A review. Livestock Prod. Sci. 12: 309-327.

Human, H.G., 2007. Livestock Manager of GWK PTY Ltd . Personel Interview. May 2007.

Louw. C.J. & Read, M., 1991. Intensive feeding and finishing of lambs and culls. Natal Sheep 5.5 Department of Agricultural Development. Natal region Pietermaritzburg : 1-4.

Maasz., D.J. 2006. The effect of supplemented light on certain production parameters of young beef bulls fed intensively. M. Tech. (Agric) dissertation, Central University of Technology, Free State, Bloemfontein.

Marie, M., Findlay, P.A., Thomas, L. & Adams, C.L., 2001. Daily patterns of plasma leptin in sheep; Effects of photoperiod and food intake. *J of Endocrinology*. 170: 277-287.

Nel, J.A., 1993. History of the Dorper. Dorper Sheep Breeders' Society of South Africa, PO Box 26, Middelburg, C.P. 5900, South Africa.

Peters, R.R., Chapin, L.T., Emery, R.S. & Tucker, H.A., 1980. Growth and hormonal response of heifers to various photoperiods. *J. Anim. Sci.* 51: 1150-1153.

Schanbacher, B.D. & Crouse, J.D., 1980. Growth and performance of growing-finishing lambs exposed to long or short photoperiods. *J. Animal Sci.* 51: 943-948.

Small, J.A., Glover, N.D., Kennedy, A.D., McCaughey, W.P. & Ward, D.R., 2003. Photoperiod effects on the development of beef heifers. *Can. J. Anim. Sci.* 721-730.

Terblanche, E., 1979. Know our small stock breeds (in Afrikaans). Printed by Human and Rousseau, Cape Town/ Pretoria.

Tucker, H.A., Peticlere, D. & Zinn, S.A., 1984. The influence of photoperiod on body weight gain, body composition, nutrient intake and hormone secretion. *J. Anim. Sci.* 59: 1610-1620.

Veekos (Sentraal Kooperatief) Beperk., 1988. The finishing of lambs in a feetlot. (In Afrikaans). Upington.

CHAPTER 2

LITERATURE OVERVIEW

2.1 Introduction

In many areas of the world, climate factors limit the productivity as well as the survival of livestock. Consequently, man has provided shelter to animals in an effort to improve their productivity. More closely controlled environments helped to increase productivity, reduce production costs and, in proportion to income, lower costs of food of animals (Tucker & Ringer, 1982).

High feeding costs is a serious restriction in the profitability in livestock production enterprises. Approximately fifty percent of the total cost of production for most classes of livestock is the result of feed costs (Van der Westhuizen *et al.*, 2004).

For optimum returns, a sound knowledge of the market requirements for particular carcasses and how they relate to the live animal, is needed. This requires an understanding of the animal's stages of maturity and the relative fat depths over the eye muscle and rump, in association with actual live weights. Accurate identification of the live animal for particular market requirements is extremely important. Relating the fatness of the animal to the amount of cover, the eye muscle and ribs can help to assess actual fat depths. Ultrasound scans can be taken for accurate determination of the fat depth.

Animals that are under-finished will be penalized in sale price. Animals that are too fat will suffer a penalty in price per kg; in addition to the cost incurred from the extra feed consumed. Currently the lamb industry aims to produce lambs that produce as much lean and as little fat as possible to compete with other meat sources (Houghton & Turlington, 1992).

2.2 Feedlot economics

Feedlots involve the provision of an artificial environment in which cattle and sheep are placed in a confined area to consume a predetermined diet. An increase in profit results from better growth of the animal and an improved carcass relative to the cost of the extra feed and other inputs. Invariably, marginal returns make it necessary to use feedlots (Bertram & Phillips, 2004). Profit margins in feedlots are minimal and any mismanagement or bad decisions will negatively influence profits. Since the purchase price and the cost of feed are the main cost components in feedlots, feed conversion ratios and average daily gain is vital to any feedlot. Feed conversion ratio affects net return more than average daily gain. When the limits of increase of daily gain are achieved, feed conversion ratio will become more and more important (Maree & Casey, 1993).

Net returns per head are determined by gross margin (selling price minus buying price) minus feed and non-feed variable costs, e.g. veterinary costs, interest, labour, fuel, transport and marketing costs. As feed costs account for 70 – 80 % of variable costs, efficiency of feed conversion is a key factor in profit achievement. Of the non-feed costs, some 80% is related to the length of time an animal is fed. Rate of gain is therefore an important determinant of feedlot economy. The total feed requirement during the stay of a steer in the feedlot can be reduced by as much as 10 % with an improvement in gain of only 200g/day (Maree & Casey, 1993).

2.3 History of the Dorper

After the first World War, increased interest developed in South Africa in crossing indigenous sheep like the Persian and Merino with a British mutton breed. As a result of circumstances such as the depression, surplus mutton and the slump in wool prices in the early 1930's, the exporting of mutton lambs received more attention.

A need originated for a fairly good mutton sheep which could produce fast growing lambs on veld conditions with a good quality carcasses. In the Karoo areas, the aim was to replace the fat-tail types with a breed that could produce an acceptable carcass. The initial need was to produce a sheep breed suitable to the demanding low rainfall areas of the north western areas of South Africa. A relatively easy-to-care sheep with an acceptable meat carcass, had to be found for these difficult circumstances (Milne,2000). The most important characteristics required for the breed were probably the following:

- Satisfactory lambing ability in the Autumn;
- Reasonable acceptable meat carcass;
- A good slaughter lamb on veld conditions at 4-5 months;
- Resistance against cold wind-rain, extremely high summer temperatures and radiation; a versatile sheep and good utilizer of tough grass and shrub veld;
- Satisfactory reproductive fitness;
- Easy-to- care without lamb end shearing problems;
- A fair amount of colour and pigmentation.

The Black Head Persian was selected as the mother breed, due to its outstanding performance especially under harsh environmental conditions. The Dorset Horn was selected for its longer breeding season in comparison to other British sheep breeds. Research on the Dorper continued and on 19 July 1950 The Dorper Breeders' Society was formed. A score card was developed with the following traits in order of importance: conformation; size; fat distribution; colour pattern; hair/wool type; and general appearance or type. From this humble beginning, the breed proved itself as a hardy mutton sheep with a top quality carcass at a relative early age (Milne, 2000).

Today the Dorper is generally recognized as one of the most popular mutton breeds in South Africa with an estimated number of over seven million. It is well adapted to a variety of veld types and climates, and is farmed over a wide

geographical range in this country. Mutton production is an important component of the agricultural sector in the extensive north-western sheep grazing areas of the Republic of South Africa. Due to the limited natural resources in these areas, it is important to increase the efficiency of mutton production within the limits of these resources (Snyman & Olivier, 2002). Dorper sheep constitute a large proportion of the sheep numbers in these areas, and it is therefore obvious that thousands of Dorper lambs are finished in feedlots every year.

2.4 Feed for maintenance, Feed conversion ratio (FCR) and average daily gain (ADG)

In almost every situation live weight gains are most economical when the rate of gain is maximized. A high rate of gain always needs a high intake. Intake is of major importance and the feedlot manager should put considerable effort into planning and management to maximize intake. The animal needs a certain amount of nutrients to maintain essential functions, hence maintenance requirements get priority. Only nutrients in excess of maintenance can be utilized for gain. A further saving in cost would be brought about by lower non-feed costs due to the reduction in length of stay (Maree & Casey, 1993).

An alternative method of measuring feed efficiency is net feed intake (NFI). Net feed intake measures the variation in feed intake beyond what is needed to support maintenance and growth requirements, and is calculated as the difference between actual feed intake and the feed an animal is expected to consume based on its body weight (BW) and ADG. Residual (or net) feed intake is defined as the quantity of feed consumed by an animal more or less in comparison to what would be expected for weight gain of the animal and its maintenance requirements (Van der Westhuizen *et al.*, 2004).

Feed efficiency has been measured as the feed conversion ratio FCR, which is feed intake divided by weight gain. Feed conversion ratio is defined as the

average quantity of feed consumed by the animal to gain one kilogram in body (live) weight (Van der Westhuizen *et al.*, 2004).

2.4.1 Genetic selection

Lambs perform according to their potential genetic and physiological abilities. The ability of lambs to take feed and produce meat differs noticeable between breeds and also within breeds. Therefore the feedlot owner must select a lamb like the crossbreeds between meat and wool, which will perform well. Age is mainly responsible for the physiological ability to exchange feed into meat – the younger the lamb, the better the performance in terms of growth and feed conversion rate (FCR) (Veekos, 1988).

Another way to reduce feed costs is through genetic selection of more efficient animals (Robinson & Oddy, 2004). Feeder lambs will gain 15–20kg in body weight in the feedlot at a rate of 200-350g per day, depending on breed, type of feed and management. Slaughter weights at equal fatness acceptable to the Southern African market should be about 24kg for the early maturing Pedi, 32-34 kg for the medium maturing Dorper, 37-40kg for the Döhne Merino and 40-43 kg for the late maturing SA Mutton Merino (Maree & Casey, 1993).

Feeding costs of animals is a major determinant of profitability in livestock production enterprises. Genetic selection to improve feed efficiency aims to reduce cost in livestock and thereby improve profitability. Traditionally, selection for growth rate has received considerable emphasis in most breed improvement schemes (Van der Westhuizen *et al.*, 2004).

For many years, beef cattle have been selected primarily on growth traits such as weaning and yearling weights, and feedlot average daily gain (ADG). As new technologies have been implemented, the progress of selecting breeding stock has become more complex. The widespread use of expected progeny

differences (EPD) by the seed stock industry has led to significant improvements in growth traits, and more recently, the industry has begun to focus on carcass quality traits. Current selection programs have not taken input costs into consideration, even though feed inputs represent the single largest variable cost in producing beef. The ability to identify livestock that consume less feed without compromising performance or carcass quality would substantially improve profitability as well as reduce the environmental impact of beef production systems (Van der Westhuizen *et al.*, 2004).

For Bonsmara cattle, under South African conditions, the genetic correlations between weaning weight and other traits contributing to feedlot profitability suggest that the indirect genetic response in these traits through the direct selection on weaning weight would be small, if any (Van der Westhuizen *et al.*, 2004).

2.5 Body measurements

2.5.1 The application of body measurements

Body size and body shape of rams can be described, using measurements and visual assessments. How these measurements of size and shape relate to the functioning of the individual is of paramount importance in the livestock production. Therefore, constant checks on the relationships between body measurements and performance traits are vital in selection programmes (Maiwashe, 2000).

A study of Fourie *et al.* (2002) investigated the relationship between the growth performance of young Dorper rams under extensive conditions and their body measurements, as well as to quantify factors affecting body measurements. Body weight is a frequent recorded variable in animal research. It is the measurement most used to evaluate growth (Otte *et al.*, 1992). Although it is an important indicator of growth, it fails to indicate the body composition of the

animals. Other measurements most commonly used in cattle include heart girth, wither height and body length. However, heart girth is generally accepted as the single most reliable variable (Benyi, 1997) for growth.

Amongst all the body measurements, the highest correlation was found between heart girth and selection index. The selection index is regarded as the most important indicator of growth in the projects. Low correlation between coat type and performance indicated that there was no difference in the growth ability with hair, a mixture of hair and wool, and wool in Dorper sheep (Fourie *et al.* 2002).

Heart girth and body length had the biggest influence on body weight in both projects. Shoulder width, chest depth, age, shoulder height and scrotal circumference also had an influence on body weight. Heart girth yielded the highest partial contribution and was, therefore, the most important contributor to the selection index. Age, body length and canon bone circumference also contributed to the selection index. The positive correlation between heart girth and post-weaning growth rate indicated that selection for heart girth could possibly lead to faster growing animals. It also lead to an increase in shoulder height and a larger frame size, which may have lead to reduced adaptability. Shoulder height also had a more significant effect on ADG than body length. The low to medium correlation between scrotal circumference and growth parameters indicated that growth potential and the reproductive ability were not strongly correlated in young performance-tested rams (Fourie *et al.*, 2002).

In general, large heart girth, body length, width and depth and canon bone circumference was positively related to growth under extensive conditions. This is however, not a hard and fast rule, as there were animals with all these characteristics that performed poorly. Body measurements and visual appraisal should, therefore, always be combined with performance test results and breeding values. Visual appraisal directed at functional efficiency in a balanced combination with performance test results, breeding values and pedigrees had

been a winning combination in the beef industry, and could also be adopted by the Dorper sheep industry (Fourie *et al.*, 2002).

Heart girth could be used to obtain estimates of body weight during periods of the year when animal management is consistent and feed resources relatively constant (Goe *et al.*, 2001).

2.5.2 Heritability of body measurements

In order to obtain higher growth capacity, increased muscularity and reduced fatness, selection of performance tested rams should be based on a selection index, which includes the performance of daily gain, LD-area (long dorsi) and fat thickness (thickness of backfat) (Liboriussen, 1995).

2.6 Ultrasound

2.6.1 Background

Livestock producers are realizing the importance of carcass trait predictability, as the livestock industry moves closer to the concept of value-based marketing and the introduction of more detailed carcass specification systems and the payment of premiums for products satisfying the requirements of specific markets; but they are faced with a dilemma because of the lack of accurate methods for measuring carcass value prior to slaughter (Houghton & Turlington, 1992).

Ultrasound has been used for evaluating carcass composition in cattle, sheep and pork. Its use has increased dramatically in recent years, thanks to improvements in ultrasound equipment and computer technology (Fernández *et al.*, 1998). The ability to evaluate carcass traits in live animals is of value to research, educational, and industry personnel (Houghton & Turlington, 1992).

There are several advantages of being able to measure carcass traits on breeding stock and with ultrasound. Live animal measurement was possible for subcutaneous fat depths and longissimus muscle area (Robinson, *et al.*, 1993). Ultrasound was considered acceptable for measuring rib-eye area and various fat thickness measures. With this the breeders could select young breeding cattle for less fat thickness, larger rib-eye size and larger rib-eye size in relation to weight, rather than rely upon progeny testing that cost time and money. Knowledge of weight, rib-eye area and fat thickness is useful for group feeding in a more uniform composition at slaughter. Rib-eye size is recognized as important by cattle producers in predicting yield grade (Turner *et al.*, 1990).

The application of ultrasound in lamb finishing programs has met with limited success. Most data indicated that weight and (or) visual estimations of fat were at least as accurate as ultrasound predictions of carcass composition. Factors such as age, sex, breed type, weight, and hip height are needed to help predict days on feed more accurately (Houghton & Turlington, 1992).

2.6.2 Plasma leptin versus ultrasound fat thickness determination

Positive relationships between circulating leptin concentrations and body fat content have been established in sheep. Leptin is mainly secreted from white adipose tissue and circulates in free and protein-bound form. At steady-state of energy balance, the plasma leptin level reflects the body fat mass and signals the extent of fat energy reserves to the hypothalamus (Altmann *et al.*, 2005).

Carcass fat could be estimated by the leptin concentration with the same accuracy as with ultrasound measurement of fat thickness. The measurement of fat thickness via ultrasound is more difficult in younger lambs because they have a thinner subcutaneous fat layer and the variability is smaller. A combination of leptin and ultrasound fat thickness clearly enhanced the precision in all groups. Leptin concentrations may serve as an accurate indicator of

quality gradings. The accuracy for the prediction of carcass fat content by plasma leptin concentration is comparable with the ultrasound fat thickness determination, which is commonly used in livestock production (Altmann *et al.*, 2005).

2.6.3 Procedure for using ultrasound

The procedure for using ultrasound involves the application of mineral oil to the area of the body to be measured, followed by the placement of a sensor or transducer on the chosen area. The basic principle of ultrasound is to measure an echo rebounding from soft tissues. After the transducer is placed in contact with the animal, the ultrasound equipment transfers electrical pulses to high-frequency sound waves, hence the name ultrasound. The sound waves travel into the body and are reflected from boundaries between different densities of tissues. The image that the ultrasound waves transmit back through the transducer is projected onto the screen of the ultrasound unit and the appropriate measurements are made (Houghton & Turlington, 1992).

In a study with pigs' data indicate no significant differences for backfat measurements between the live animal and standing carcass were indicated but significant differences between the live animal and the hanging carcass were indicated. In all cases, backfat measurements taken from the hanging carcass exceeded those of the live animal or standing carcass. Significant differences were also found for longissimus muscle area between the live animal, standing carcass, and hanging carcass. Although similar data does not exist for sheep and beef cattle, it is reasonable to assume that the carcass position also influences carcass measurements in these species (Houghton & Turlington, 1992).

2.6.4 Application of ultrasound

When discussing the accuracy of ultrasound, there is another point that should be considered that relates to the correlation between ultrasound measurements of backfat and longissimus muscle area to their corresponding carcass measurements. Carcass measurements are indicators of total carcass muscle and leanness. It may be more appropriate to correlate ultrasound measurements of backfat and longissimus muscle area to total carcass muscle or lean muscle mass, rather than to the carcass measurements themselves (Houghton & Turlington, 1992).

The accuracy of ultrasound in predicting carcass traits is variable and dependent on species, ultrasonic instrumentation and (or) the skill of the technician. According to Houghton & Turlington (1992) the ranges of correlation coefficients for the carcass traits as predicted by ultrasound to the respective carcass measurement are as follows: sheep (fat 0.42 to 0.95: longissimus muscle 0.36 to 0.79) .

Results of several studies showed that ultrasound and linear measurements accounted for more variation in yield of saleable product than did live weight. These results led to the conclusion that percentage of kidney, pelvic, and heart fat is an important predictor of saleable yield; therefore, ultrasound and linear measures were not reliable predictors in themselves because these measurements could not give a direct measure of this carcass trait. It was concluded that more accurate ultrasound measures are needed to predict compositional differences in live lambs. Until this occurs, researchers have suggested that a visual estimation of body fat by a trained livestock evaluator is still the best predictor of market lamb cutability. These results led to the conclusion that weight (live or carcass) was the primary determinant of lean mass in this population of lambs. Although fat and muscle measures were of little value in predicting carcass composition, it was reported that fat measures at

the $\frac{3}{4}$ position over the loin eye were better indicators of carcass composition than measurements on the midline (Houghton & Turlington, 1992).

Ultrasound is of potential use in educational and research efforts of pigs, sheep and beef cattle. From an industrial standpoint, however, there seems to be uncertainties about the usefulness of ultrasound. Pig data suggested that ultrasound is useful under field conditions. In contrast, conflicting data exists for sheep. The small variation that exists in fat depth and muscle area in lambs is a contributing factor to the lack of consistent data as it relates to the usefulness of ultrasound. Therefore, more precise equipment is required before ultrasound will be useful on a commercial basis in the lamb industry (Houghton & Turlington, 1992).

Individual longissimus muscle measurements, as estimated by ultrasound, may not be accurate enough for commercial or research purposes. In contrast, when these measurements are used to evaluate a group or treatment, the data is probably useful. It is evident that errors exist in this technology, but if it is assumed that the error is random across groups and enough livestock are measured, it is probably safe to say that on average, the data obtained from ultrasound measurements are relatively accurate (Houghton & Turlington, 1992).

2.7 Supplement light

2.7.1 Introduction

In many segments of animal agriculture artificial lighting is widely used to increase efficiency of livestock facilities (Hackett & Hillers, 1979). The daily photoperiod has affected reproductive efficiency of many species. Over the last several decades there has been a sharp increase in housing domestic food-producing animals in close confinement, thereby permitting more regulation of

their environments and increase the quality of their productivity (Tucker & Ringer, 1982).

While almost all animals respond to the photoperiod in some way, it is usually associated with reproductive events. Poultry producers use lighting to stimulate layers while sheep and horse breeders manipulate the breeding season with light exposure. Though not seasonal breeders, reproduction in cattle can be affected by the photoperiod - long days hasten puberty in heifers relative to natural day length (Dahl, 2001a; Hansen 1985). The results of a study of Tucker & Ringer (1982) suggest that the photoperiod may be manipulated to stimulate reproduction and body growth, increase milk production and the efficiency of feed utilization, and hasten puberty in several domestic species.

The photoperiod is defined as the duration of light an animal is exposed to within a 24-hour period. Animals use the photoperiod to track the length of the day. A long-day photoperiod is considered exposure to 16-18 hours of light along with a six- to eight-hour period of darkness. In contrast, a short-day photoperiod is usually eight hours of light and 16 hours of darkness (Dahl, 2001b).

Improved growth performance with an extended photoperiod has been reported for cattle exposed to light intensities greater than or equal to 104 lux (Peters, *et al.*, 1980). Other factors that may affect the photoperiod-induced changes in BW gain are intensity of supplement light, and pattern and duration of supplement light. Forbes (1982) indicated that intensities of artificial light less than 100 lux may not have been sufficient for animals to recognize the SL as being part of the light phase. It also appears that changes in light intensity from approximately 300 to 600 lux had no effect on response. This is possibly because both intensities are probably above the threshold level of intensity that is perceived by cattle as light. Certainly, photoperiodic responses have been achieved when the light intensity of the supplementary or artificial light has been approximately 200 lux (Zinn *et al.*, 1989; Enright, *et al.*, 1995).

The focus of a study of Tucker *et al.* (1984) was on photoperiodic regulation of growth. Currently, most commercial applications of lighting schemes for domestic farm mammals are designed to provide light throughout the night. Recent studies suggest, however, that continuous lighting does not stimulate nutrient intake or growth rates. The results show controlled daily light (L): dark (D) cycles affect body growth, carcass composition, nutrient intake and hormone secretion in sheep, goats and cattle (Tucker *et al.*, 1984).

With costs escalating, the feedlot owner must find ways to produce a quality carcass cheaper and more effectively saving costs and time. The manipulation of the photoperiod is a tool that can be used to increase productivity. It is important that the growth stimulating effect of long day length is confirmed in other situations, because of the potential commercial value should it be found to apply under a wide range of conditions. Livestock producers and researchers are continuously searching for technologies that will improve productivity and profitability. The question arises: can the photoperiod be used in sheep in a feedlot as in other animals with the same successes (Dahl, 2001)?

2.7.2 The effect of supplement light on different species

2.7.2.1 Dairy cattle

Dairy producers are constantly searching for new management techniques to improve production efficiency and cash flow. Photoperiod management has attracted interest lately as a cost effective method of increasing production in lactating cows. This is because the daily milk production of cows exposed to long days with 16-18 hours of light and 6-8 hour of darkness, increased on average two liters/day, relative to those on natural photoperiods (Dahl *et al.*, 2000, Dahl, 2001a).

Recent studies have shed light on the potential physiological mechanism for the increase in yield of cows on long days. Differences in light exposure alter the secretion of a number of hormones. Indeed, these hormonal shifts drive the commonly observed changes in reproductive activity in other species. The first hormone impacted by the photoperiod is melatonin, which is secreted in response to darkness. Thus, in cows and other animals, a long day actually reduces the duration of elevated melatonin. Animals use this pattern of melatonin to track day-length, and then alter the secretion of hormones (Dahl, 2001a).

It is known that cows on long days eventually increase intake to meet the increased demand for energy for milk production. Regardless of lactational stage, 16L:8D stimulated milk yield and dry matter intake of cows during the autumn to winter seasons (Peters *et al.*, 1981). Lactation, however, is not the only time during the annual milk production cycle when the photoperiod treatment is recommended. Recent studies suggested that appropriate treatment of the dry cow can markedly enhance milk yield in the subsequent lactation. Cows were treated with either long or short (8L:16D) days during the entire 60-day dry period. Cows were then exposed to a natural photoperiod after parturition, surprisingly, over the first 120 days of lactation, cows treated with short days when dry produced 3.2 liter/day more milk than the cows on a long days during the dry period. Thus, in contrast to the benefits of long day photoperiod for lactating cows, treatment with short days is recommended for dry cows (Dahl, 2001a).

Photoperiod management offers dairy producers a novel tool with which the efficiency of milk production can be improved. It is cost effective on dairies of all sizes, but economics of scale on larger dairies enhance the returns (Dahl, 2001a).

2.7.2.2 Beef cattle

Investigations with beef cattle into the effects of day length on growth have produced a variety of results (Phillips *et al.*, 1997). Photoperiod management can be used to improve heifer growth and maximize accretion of lean tissue, including mammary parenchyma (Dahl & Peticlerc, 2003). Increased rate of gain of heifers supplemented with 16L:8D was associated with greater consumption of feed, which commenced approximately eight weeks after initiation of 16L:8D photoperiods. Heifers given 16L:8D were more efficient in converting feed into weight gain (Peters *et al.*, 1980).

Phillips *et al.*, (1997) reported that by extending the photoperiod for cattle in winter reduced body fatness in both steers and heifers and increased the time heifers spent lying down, but that there were no major effects on growth rate or food intake. The photoperiod induced growth of cattle appeared to be a gonad-dependent phenomenon as 16L:8D increased average daily gain 9.8% in intact Holstein bulls, whereas there was no significant effect in Holstein steers (Tucker *et al.*, 1984).

Maasz, (2006) researched the effect of supplementary light on certain productive parameters of young beef bulls fed intensively and found that in bulls subjected to 24 hours of light, the average daily gain was 11.5% higher and in the 16 hours of light and 8 hours darkness group, the average daily gain was 10% higher than animals exposed to normal light. Extended photoperiod has a positive effect on ADG and FCR of beef bulls under intensive feeding conditions. Animals can be fed more economically to higher weights and for longer periods because of less fat accumulation. Currently there is no proof that supplemented light has a positive effect on castrated animals (Fourie *et al.*, 2006).

2.7.2.3 Poultry

Light management can be an important component of broiler management. Specific light wavelength and light intensity are important in behavioral modification while exposure of broilers to darkness is essential to bird health (Classen, 2000).

Manipulation of the photoperiod has been practiced commercially for more than 60 years to control the onset of egg production and to stimulate egg laying and regulate body growth in chickens (Tucker & Ringer, 1982). In the natural environment of the temperate zones, chickens exhibit annual variations in reproductive activity. However, through maintenance of continuous feed supply and manipulation of photoperiod, reproductive activity in chickens can be sustained throughout the year. Specifically, photoperiod regulation is used to control the onset of egg production and to maintain sustained egg production in commercial flocks. Without management of the photoperiod there would be marked seasonal variations in the price and availability of eggs and broilers (Tucker & Ringer, 1982).

Greater egg production can be sustained by exposure to 6 to 10 hours of light per day. Progressively longer days maximize the egg-laying rate, while progressively shorter days reduce egg production. The latter response is more pronounced than the former. In general, exposing chickens to increased periods of daily light beyond 17 hours in duration, yields no further increase in number of eggs laid. The minimum of lighting required for maximum egg production is between 2 and 10 lux (Tucker & Ringer, 1982).

2.7.2.4 Pigs

Neonatal death loss in pigs is of major importance to pork producers as between 20 to 25% of pigs farrowed alive die before weaning. Progress has been made

in nutrition and breeding programs but maternal performance of sows during lactation has not improved. Of the neonatal mortality, 20 to 30% is due to a lack of adequate nutrition and 20 to 50% is due to crushing by the sow. It is probable that an increased energy intake by the neonatal pigs would decrease mortality before weaning. One method of increasing the energy intake of the piglet would be to increase the milk production of the sow. Milk production has been shown to be increased as the photoperiod of the sow during lactation is increased from 8 to 16 hours and an increase in piglet survival was also noted (Mabry *et al.*, 1983).

According to a study of Berger *et al.* (1980) the extended photoperiod did not influence a beneficial effect on weight gain or feed efficiency of boars, barrow or gilts. Hoagland *et al.* (1981) found that supplemental lighting which extended the photoperiod to 15 hours/day did not significantly increase serum (prolactin) PRL in young boars. Mahone *et al.* (1979) found that there was no difference in weight between boars in control and the treated group until 24 weeks of age, but that an artificially extended photoperiod during short to increasing day length accelerated the onset of mating behavior in boars.

Reports of photoperiodic effects on pig reproduction have often given conflicting conclusions (Ntude *et al.*, 1979). The effect of photoperiodic stimulation on the initiation of puberty in boars is unknown (Mahone *et al.*, 1979).

Neither male nor female pigs grow faster in response to various photoperiods (Tucker & Ringer, 1982). There is no evidence that the photoperiod affects growth of pigs (Forbes 1982) and it is concluded that for pigs intended for slaughter, increased light in the barns is of questionable benefit (Ntude *et al.*, 1979).

2.7.2.5 Sheep

An extended photoperiod can influence the reproduction and growth of dairy cattle, but very little is known about the effects on sheep reared outdoors. Voluntary food intake of seasonal ruminants (sheep, red deer) increases in long days (spring – summer) and decreases in short days (autumn – winter) even when the food supply is constant and unlimited. The animals feed preferentially during daylight hours so that they ingest food faster and over a longer period in long days than in short days. Various studies have suggested that rumen capacity and metabolic rate are greater in long summer days than in winter (McEwan *et al.*, 2005).

Forbes *et al.* (1979) and Schanbacher & Crouse (1980) reported in studies on lambs that longer photoperiods stimulated body growth rates and carcass weights of lambs. Forbes *et al.* (1979) reported an increase in live weight gain of castrated males and intact ewe lambs exposed to 16L:8D photoperiods as compared with animals exposed to 8L:16D. Half of the lambs were fed on a concentrated diet *ad libitum*, whereas the other half were restricted to gain 70g/day body weight. In comparison 8L:16D, 16L:8D stimulated weight gain of lambs fed *ad libitum* (230 vs 204 g/d) and restricted (154 vs 123 g/d) diets. In pair-fed animals, live weight gain was significantly greater under 16 hours per day lengths, but most of these differences were ascribed to increased gut fill and pelt weight (Forbes *et al.*, 1979). An increase in growth rate, such as that caused by exposure to long days, would therefore be followed by an increase in *ad libitum* food intake. The effect is more marked in goats and Soay (unimproved) sheep than in lowland breeds of sheep or in cattle. When food is offered *ad libitum*, long day length stimulates voluntary intake, probably as a result of the increased nutrient requirements of the additional growth. Pair feeding, to remove nutritional effects, resulted in longer, leaner carcasses under long days, without an effect on carcass weight (Forbes, 1982).

Not only did lambs grow more rapidly and reach market weights sooner when exposed to long photoperiods, but feed conversion was also more efficient. Increased feed consumption by lambs exposed to long photoperiods appeared necessary for accelerated rates of gain, but the physiological reason for increased feed consumption was not known. Long photoperiods may increase rates of gain indirectly by stimulating appetite and feed consumption. On the other hand, increased consumption may be requisite to the increased nutritional requirements of the rapidly growing animal. The first explanation seems more likely, because lambs are known to gain most rapidly when feed consumption is maximized (Schanbacher & Crouse 1980).

In a research of Faulconnier *et al.* (2001) the results suggested that adult sheep kept the ability to anticipate seasonal changes in feed resources, since their AT (adipose tissue) and muscle metabolism was sensitive to changes in day length even when feed intake was kept constant. In a study of Bocquier & Thériez (1990) no effects of photoperiod treatment could be detected on milk yield and fat content in dairy ewes, although milk protein concentration was lower under a long photoperiod.(15.5L:8.5D) versus (8.5L:15.5D). McEwan *et al.* (2005) reported an effect of the photoperiod on the bacterial population composition of the rumen ecosystem, which was independent of dietary composition and it was proposed that the differences were most likely because of the photoperiod-driven differences in food intake.

During winter, continuous lighting was less effective in stimulating body growth than natural short-day photoperiods in sheep (Hulet *et al.*, 1968). In cattle continuous lighting was less effective than 16L:8D (Peters *et al.*, 1980). Therefore, a period of dark appeared necessary for maximal stimulation of growth. However, light does not need to be present as a continuous block of 16 hours to stimulate growth. Long duration photoperiods of 16L:8D can be mimicked by coupling short durations of light with brief “flashes” of light given at a precise time during the dark period. Lambs exposed to a photoperiod of

7L:9D:1L:7D gained weight more rapidly than lambs exposed to 8L:16D (Schanbacher & Crouse, 1982). It is not essential to supply 16 hours of continuous light each day (Tucker & Ringer, 1982).

The role of gonads on the photoperiod induced growth differs between sheep and cattle. In sheep, Schanbacher & Crouse (1980) observed that long-duration photoperiodic stimulation of growth was similar in 10-week-old castrated and intact ram lambs. Thus the body growth response to photoperiod in sheep is independent of the gonads. Wethers as well as intact male and female sheep grow faster in response to a 16-hours period of daily light than controls given 8 hours of light daily (Tucker *et al.*, 1984).

Forbes *et al.* (1979) observed that at least half of the increased daily weight gains in sheep in response to long days was associated with changes of the contents of the gastrointestinal tract. Several studies suggested that longer periods of daily illumination led to increased carcass weight at slaughter. Fat and protein percentages in sheep carcasses were not markedly affected by photoperiod. The growth response to long days may be limited to ruminants (Tucker & Ringer, 1982).

2.7.3 Photoperiod and hormone secretion

Recent years have seen a significant advance in the understanding of the central mechanisms regulating food intake, appetite and metabolic regulation. Most research has used rodent species, but a more expansive understanding of the neuroendocrine control of appetite can be achieved by the study of other species. Sheep provide many advantages for neuroendocrine studies and work with this species has contributed significantly to the understanding of the regulation of appetite. Sheep are an excellent species for the study of neuroendocrine systems because of the ease of serial measurements of hormone secretion (Henry, 2003).

The hypothalamus is integral to the regulation of energy homeostasis and the secretion from the pituitary gland. Consequently, hypothalamic systems may have a dual purpose in regulating both neuroendocrine function and appetite. Various physiological models, including chronic food-restriction or photoperiodically driven changes in voluntary food intake, add further perspective to this issue. In this regard, sheep provide an innovative model whereby long-term changes in body weight or extended feeding rhythms can be investigated. Chronic or severe under nutrition perturbs the secretion of hormones from the pituitary gland, thus impacting on reproduction, growth, stress and metabolic processes (Henry, 2003).

The secretion of hormones, by the pineal, which have important influences on the hypothalamus is thus largely under the influence of the nervous system. The pineal gland has an important role in controlling the timing of cyclical activity in sheep. The gland is sensitive to photoperiod via the secretion of the hormone melatonin (Güdoğan, *et al.*, 2003). Melatonin levels are high during dark periods and low during light periods. These differences in the pattern of melatonin secretion act as a signal indicating day length to the neuroendocrine axis (Henry, 2003).

The presence of a direct retino-hypothalamic neural pathway suggests the possibility of direct effects of light on the control of pituitary hormone secretion and voluntary food intake (Forbes, 1982). In seasonal species like sheep, photoperiod influences appetite and body weight, and thereby interacts with imposed nutritional treatments. The exact mechanisms by which photoperiod controls body functions are not well understood, but it is hypothesized that melatonin plays a substantial role in the endocrine control of animal metabolism. The proposed pathway was that light (or lack of) influences the eye, which in turn signaled the pineal gland to control release of melatonin that acted on the theoretical hypothalamic pulse generator to influence the rest of the endocrine system (Lawson & Kennedy 2000). The plasma concentrations of melatonin in

cattle have been shown to increase 1.6 to 5.1-times in response to the onset of darkness. The plateau is reached within two hours of darkness and melatonin concentrations remain high until the onset of light. Recent work suggested that inhibition of melatonin secretion by extended day length may be important in animal production (Kennedy, 2001).

The mechanism whereby the photoperiod controls growth in sheep and cattle has not been elucidated, but the anterior pituitary hormone prolactin could be involved. Secretion of prolactin is consistently raised by long days, but proof is lacking that prolactin is casually involved in the increased growth. Of all the hormones measured in cattle, prolactin is most affected by a changing photoperiod. In sheep 16 hour days increase serum prolactin and 8-hour days reduce it (Tucker & Ringer, 1982). Growth hormone and insulin are unaffected by day length, whereas there is conflicting evidence for effects of daylength on thyroxine and corticosteroids (Forbes, 1982). The positive relationship between serum prolactin and growth rate in a study of (Schanbacher & Crouse 1980) provides support for suggestion that prolactin may stimulate growth in the ruminant.

2.7.4 Photoperiod and reproduction in sheep

Unlike most livestock species, sheep are widely known as animals with marked seasonality of breeding activity. The annual cycle of daily photoperiod has been identified as the determinant factor of this phenomenon. Photoperiod, environmental temperature, nutrition, social interaction and hormones are among the factors that affect reproductive activity of the sheep. Sheep are considered “short-day breeders” because reproductive activity is initiated in response to decreasing length or daylight (Güdoğan, *et al.*, 2003).

Soay rams housed under opposite photoperiods differed profoundly in physiological and endocrine status. In short days they were reproductively active

with high circulating concentrations of testosterone, and concentrations of prolactin were low, whereas in long days they were reproductively inactive, with low testosterone, and prolactin concentrations are high. In addition, voluntary food intake increased in long days and decreased in short days (McEwan *et al.*, 2005).

Sheep and goats exhibit marked seasonal variations in sexual activity. In many breeds of sheep, estrous cyclicity in females (ewes) and sexual aggressiveness, testis size, and sperm production in males (rams) were minimal from spring until late summer. Maximal sexual activity occurs in autumn, coincident with the decreasing duration of daily light (Tucker & Ringer, 1982).

The seasonal pattern of reproduction, coupled with the duration of gestation, ensures that lambs are born in the spring. Shelters provided in modern intensive sheep-farming operations may permit the development of methods to overcome seasonal anestrus and thereby distribute lamb production throughout the year. Shortening the time to puberty and breeding could lead to more efficient production of food from domestic mammals (Tucker & Ringer, 1982).

2.7.5 Photoperiod and temperature

Numerous environmental factors, acting separately or collectively, affect the animal performance and the efficiency of livestock production. Ambient temperature and photoperiod are two factors believed to significantly affect performance of growing-finishing lamb. An evaluation of these environmental constraints provides a better understanding of normal seasonal variation in lamb performance and provides a basis for selecting those environmental conditions that improve the overall efficiency of lamb production. This information; for design and management of confinement facilities, could be used to intensify sheep production systems (Schanbacher *et al.*, 1982).

Ambient temperature was also found to be an important determinant of growth rate in lambs. Lambs converted feed-to-liveweight gain most efficiently at both photoperiods when exposed to the 18 °C environment. Wool growth was similar for lambs exposed to 16L:8D and 8L:16D photoperiods, but was reduced ($P<0.05$) by exposure to increasing environmental temperatures. These results suggest that environmental temperature and the photoperiod independently contribute to the growth and performance of confinement-reared ewe lambs and that each of these variables can be adjusted to optimize the efficiency of lamb production (Schanbacher, *et al.*, 1982).

2.8 References

Altmann, M., Sauerwein, H. & Von Borell, E., 2005. Relationship between plasma leptin concentrations and carcass composition in fattening mutton: a comparison with ultrasound results. *Journal of Animal Physiology and Animal Nutrition*. 89: 326 -330.

Benyi, K., 1997. Estimation of live weight from chest girth in pure and crossbred West African goats. *Trop. Anim. Health Prod.* 29: 124-128.

Berger, T., Mahone, J.P., Svoboda, G.S., Metz, K.w. & Clegg, E.D., 1980. Sexual maturation of boars and growth of swine exposed to extended photoperiod during decreasing natural photoperiod. *J. Anim. Sci.* 51: 672 – 678.

Bertram, J. & Phillips, A., 2004. Basic Guidelines for a Feetlot Operation. *Anim. Prod. Alice, Springs.* 1- 6.

Bocquier, F. & Thériez, G., 1990. Relationships between secretory patterns of growth hormone, prolactin and body reserves and milk yield in dairy ewes under different photoperiod and feeding conditions. *British J. of Anim. Prod.* 51: 115 -125.

Classen H.L., 2000. Barn of the future lighting programs. *Ministry of Agriculture and food.* 1-5.

Dahl, G.E., Buchanan, B.A., & Tucker, H.A., 2000. Photoperiodic effects on dairy cattle: A review. *J. Dairy Sci.* 83: 885-893.

Dahl, G.E. 2001a. Photoperiod Management of Dairy Cattle. *Ministry of Agriculture and Food.* 1-6.

Dahl, G.E., 2001b. Photoperiod control improves production of dairy cows. *Feedstuffs: a weekly newspaper for the feed manufacturer, feed jobber, feed broke and feed dealer.* 73: 10-19.

Dahl, G.E. & Peticlerc, D. 2003. Management of photoperiod in dairy herd for improved production and health. *J. Anim. Sci.* 81:11-17.

Enright, W.J., Zinn, S.A., Reynolds, V.S. and Roche, J.F., 1995. The effect of supplementary light on winter performance of prepubertal and post pubertal Friesian Heifers. *Irish J. Agric. and Food Research.* 34: 107 -113.

Faulconnier, Y., Bonnet, M., Bocquier, F., Leroux, C. & Chilliard. 2001. Effects of photoperiod and feeding level on adipose tissue and muscle lipoprotein lipase activity and mRNA level in dry non-pregnant sheep. *Brit. J. Nutr.* 85: 299-306.

Fernández. C. , Gracia, A., Vergara, L. & Gallego, L., 1998. Using ultrasound to determine fat thickness and longissimus dorsi area on Manchego lambs of different live weight. *Small Ruminant Research.* 27: 159-165.

Forbes, J.M., El Shahat, A.A., Jones, R., Duncan, J.G.S., & Boaz, T.G., 1979. The effect of day length on the growth of lambs. *Anim. Prod.* 29: 33-42.

Forbes. J.M., 1982. Effects of lighting pattern on growth, lactation and food intake of sheep, cattle and deer. *L. Prod. Sci.* 9:361-374.

Fourie, P.J., Neser, F.W.C., Olivier, J.J. & Van der Westhuizen, C., 2002. Relationship between production performance and body measurements of Dorper rams. *S. Afr. J. Anim. Sci.* 32: 256-262.

Fourie, P.J., Maasz, D.J. & Umesiobi, D.O., 2006. The effect of supplementary light on certain productive parameters of young beef bulls fed intensively. *S. Afr. J. Anim. Sci.* 36 : 59 – 62.

Goe, M.R., Alldrege. J.R. & Light, D., 2001. Use of heart girth to predict body weight of working oxen in the Ethiopian highlands. *Livestock Prod. Sci.* 69: 187-195.

Güdoğan, Baki, D. and Yeni, D., 2003. Reproductive seasonality in sheep. *Anim. Sci.* 53: 175 -179.

Hackett. M.R. & Hillers, J.K., 1979. Effects of artificial lightning on feeder lamb performance. *J. Anim Sci.* 49: 1-4.

Hansen, P.E., 1985. Seasonal modulation of puberty anestrus in cattle: A review. *Livestock Prod. Sci.* 12: 309-327.

Henry, B.A., 2003. Young investigator perspectives. Links between the appetite Regulating systems and the Neuroendocrine Hypothalamus: Lessons from the Sheep., *J. of Neuroendocrinology.* 15: 697-709.

Hoagland, T.A., Diekman, M.A. & Malven, P.V., 1981. Failure of stress and supplemental lighting to affect release of prolactin in swine. *J. Anim. Sci.* 53: 467 - 472.

Houghton, P.L. & Turlington, L.M., 1992. Application of ultrasound for feeding and finishing Animals: A Review. *J. Anim. Sci.* 70: 930 – 941.

Hulet, C.V., Price, D.A. & Foote, W.C., 1968. Effects of variation in light, month of year and nutrient intake on reproductive phenomena in ewes during the breeding season. *J. Anim. Sci.* 27: 684-690.

Kennedy, A.D., 2001. The effect of supplemental light on growth, carcass composition and reproductive development of beef cattle. Agri-Food Research Development Initiative. 98-173.

Lawson, T.J. & Kennedy, A.D., 2000. Inhibition of nighttime melatonin secretion in cattle: threshold light intensity for dairy heifers. *Can. J. Anim. Sci.* 81: 153-156.

Liboriussen, T. 1995., Genetic parameters for daily gain, muscle area and fat thickness in sheep. Paper presented at European Association for Animal Production, Prague.

Maasz, D.J. 2006., The effect of supplemented light on certain production parameters of young beef bulls fed intensively. M Tech (Agric) dissertation, Central University of Technology, Free State, Bloemfontein.

Mahone, J.P., Berger.T., Clegg, E.D. & Singelton, W.L.,1979. Photoinduction of puberty in boars during naturally occurring short day lengths. *J. Anim. Sci.* 48: 1159 -1164.

Maiswashe, A.N., 2000. The value of recording body measurements in beef cattle. M.Sc (Agric) dissertation, UOFS, Bloemfontein.

Mabry, J.W., Coffey, M.T. & Seerley, R.W., 1983. A comparison of an 8- versus 16- hour photoperiod during lactation on suckling frequency of baby pig and maternal performance of the sow. *J. Anim. Sci.* 57: 292 – 295.

Maree, C & Casey, N.H., 1993. *Livestock Production Systems principals and practice.* Brooklyn: Agri-Development Foundation.

McEwan, N.R., Abecia, L., Regensbogenova, M., Adam, C.L., Findlay, P.A. & Newbold, C.J., 2005. Rumen microbial population dynamics in response to

Photoperiod. The Society for Applied Microbiology, Letters in Applied Microbiology, 41:97 – 101.

Milne, C., 2000. The history of the Dorper sheep. Small Ruminant Research. 36: 99-102.

Ntunde, B.N. Hacker, R.R. & King, G.J., 1979. Influence of photoperiod on growth, puberty and plasma LH levels in gilts. J. Anim Sci. 48: 1401 -1406.

Otte, M.J., Woods, A.J. & Abuabara, Y., 1992. Live weight estimation of cattle by scale and tape – A method comparison study. Trop. Anim. Health Prod. 24, 109 – 114.

Peters, R.R., Chapin, L.T., Emery, R.S. & Tucker, H.A. 1980. Growth and hormonal response of heifers to various photoperiods. J. Anim. Sci. 51: 1150-1153.

Peters, R.R., Chaplin, L.T., Emery, R.S. & Tucker, H.A., 1981. Milk yield, Feed intake, prolactin, growth hormone, and Glucocorticoid response of cows to supplemented light. J. Dairy Sci. 64:1671-1678.

Phillips, C.J.C., Johnson, P.N. & Arab T.M., 1997. The effect of supplementary light during winter on the growth, body composition and behaviour of steers and heifers. British Soc. Anim. Sci. 65: 173 -183.

Robinson, D.L., Hammond, K. & McDonald, C.A., 1993. Live Animal Measurement of Carcass Traits: Estimation of Genetic Parameters for Beef Cattle. J. Anim. Sci. 71: 1128-1135.

Robinson, D.L. & Oddy, V.H., 2004. Genetic parameters for feed efficiency, fatness, muscle area and feeding behaviour of feedlot finished beef cattle. *L.Prod. Sci* 90: 255-270.

Schanbacher, B.D. & Crouse, J.D., 1980. Growth and performance of growing-finishing lambs exposed to long or short photoperiods. *J. Animal Sci.* 51: 943-948.

Schanbacher, B.D. Hahn, G.L. & Nienaber, J.A., 1982. Effects of contrasting photoperiods and temperatures on performance traits of confinement-reared ewe lambs. *J. Anim. Sci.* 55: 620- 626.

Snyman, M.A. & Olivier, W.J., 2002. Productive performance of hair and wool type Dorper sheep under extensive conditions. *Small Ruminant Reseach.* 45: 17-23.

Tucker, H. A. & Ringer, R.K., 1982. Controlled photoperiodic environments for food animals. *American Association for the advancement of Science.* 216: 1381-1386.

Tucker, H.A., Peticlere , D. & Zinn, S.A., 1984. The influence of photoperiod on body weight gain, body composition, nutrient intake and hormone secretion. *J. Anim. Sci.* 59: 1610-1620.

Turner, J.W., Pelton, L.S. & Cross,H.R. 1990. Using live animal ultrasound measures of ribeye area and fat thickness in yearling Hereford bulls. *American Soc. Anim. Sci.* 68: 3502 -3506.

Van der Westhuizen, B., Van der Westhuizen, J. & Schoeman , S.J., 2004. Genetic variance components for residual feed intake and feed conversion ratio

and their correlations with other production traits in beef bulls. S. Afr. J. Anim. Sci. 34: 257-264.

Veekos (Sentraal Koöperatief) Beperk. 1988. The finishing of lambs in a feedlot. (In Afrikaans). Upington.

Zinn, S.A., Chaplin, L.T., Enright, W.J. and Tucker, H.A., 1989. Failure of photoperiod to alter body growth and carcass composition in beef steers. J. Anim. Sci. 67: 1249 – 1257.

CHAPTER 3

MATERIALS AND METHODS

3.1 Study site

The research was conducted between September and October 2007 on the farm Renswoude, 30° 33,256' S latitude, 22° 52,622' E longitude at an altitude of 1115 m above sea level, in the Vosburg district of the Northern Cape in South Africa.

3.2 Animals

For this research trial 120 Dorper lambs, 115 ± 10 days of age, weighing 29.76 ± 0.82 kg, were used. All the animals were divided into three homogeneous groups (40 animals/group of which 20 were intact males and 20 castrated males). The animals were housed in open pens (40/pen) and weighed every seven days. The lambs were born and raised on natural veld conditions with natural light, until they were ready to be taken to the feeding pens. However, in the year the research was conducted (2007) this area received very little rain causing the lambs to be in a poor condition.

As soon as the animals arrived at the feeding pen, they were treated for internal and external parasites (Bertram & Phillips,2004). The animals were adapted to the feeding pen for a period of seven days. When the lambs arrived at the feeding pens the following treatments were applied:

- Group 1: The lights were manually switched on at dark, half an hour before sunset, so that the animals did not experience natural sunset before the beginning of supplemented light. This group received 24 hours of light.

- Group 2: The lights were switched on by means of an automatic timer and the duration was adjusted twice a week as the daylight increased in order to expose the lambs to 16 hours light and 8 hours darkness/day.
- Group 3: This group served as the control group and only received natural photoperiods (NP). The pen was far away from both group 1 and 2, preventing artificial light to reflect on this group and have an influence on the natural light conditions.

3.3 The feeding regime

For the experiment, Oranjeriver feed pellets were used. The nutrient constituents of the feeding pellets were:

Protein	120 g/kg
Fat	25 g/kg
Fibre	200 g/kg
Calcium (Ca)	10 g/kg
Phosphorous(P)	2 g/kg
Moisture	120 g/kg

The animals were fed *ad libitum* three times a day at 7h00, 12h00, and 17h00 respectively. The feeding-troughs were cleaned every time before fresh pellets were given. The left over feed was removed and weighed. After the adaptation phase of seven days the animals were group fed (40 animals per group) *ad libitum* for 35 days on a diet containing 9.5 MJ ME/kg DM and 12% CP.

During the first week the lambs received a changeover diet with additional roughage in the form of chopped dry Lucerne. Each group received 65% (23.8kg) dry lucerne and 35% (13.2kg) feed pellets on the first day. On day three they received 20% (15kg) dry lucerne and 80% (60 kg) feed pellets. On day six (the last day of the adapting phase) all the groups received only 8% (5kg) lucerne

and 92% feed pellets. After all the animals were weighed, scanned with a ultrasound scanner and all the body measurements taken they only received feed pellets for the rest of the 35 day trial. Each lamb was weighed and total feed intake per pen was calculated weekly.

3.4 Facilities

- **The Feeding pens:** The three groups of lambs were kept in different pens of the same size. The pens were situated 300 meters from each other with buildings and trees in between to ensure that the light from the different groups could not affect each other.

The specifications of the feeding pens (per 40 animals) were as follows:

Size of the pens: 88m²

Shade: 20.3 m²

The feeding troughs 8.7m (in length)

Water troughs 1.7m

- **Lighting:** Two high pressure sodium lights mounted 2.5m above the ground on each side of the pen was used in the 24 hour and 16 hour groups. The lights were switched on with an electronic timer when the light intensity reached 60 lux. The timer and the duration were adjusted twice a week as daylight increased. The lights provided an average light intensity of 145 lux measured at eye level with a digital illumination meter (INS DX 200). (Kennedy 2001; Kendall, *et al.*, 2003; Kennedy *et al.*, 2004; Peters *et al.*, 1980; Forbes *et al.*, 1979).

3.5 Ultrasound measurements

The back fat thickness and EMA were measured with an ultrasound scanner on day 1 and day 35 of the research period.

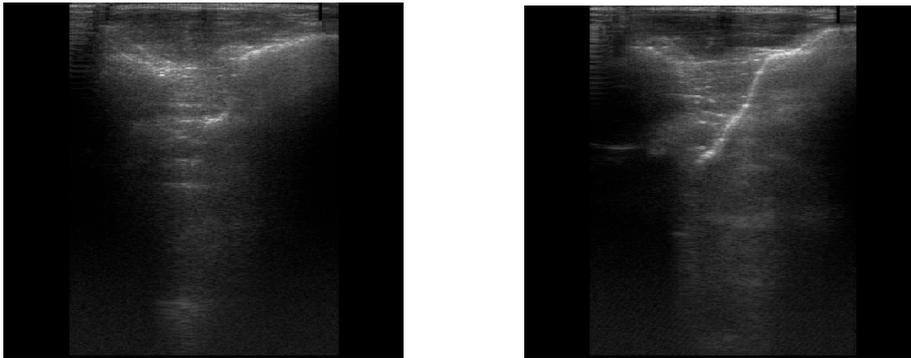


Figure 3.1 Ultrasound images of the eye muscle area and fat thickness on the rump.

Ultrasonic measurements were taken by a trained ultrasound technician from the Grootfontein Agricultural College in Middelburg using a PIE Medical Falco 100 ultrasound scanner. The location of transducer placement by palpation was between the 12th and 13th ribs on the left side of each animal. Before contact with transducer, the location was shorn, oiled, dirt free and then oiled again. A superflab guide was used to ensure proper contact between the flat ultrasound transducer and the curvature of the animal's back. All the animals were measured on day 1 and day 35. Other data collected included weight of animal when ultrasonic images were taken (Shephard *et al.*, 1996).

3.6 Slaughter of Animals

At the end of the feeding trial, all the animals were taken to the local abattoir at Vosburg, 10km from the experimental farm and slaughtered on the same day. The body weight, warm carcass weight, cold carcass weight, grading and dressing % for each group were determined. The grading of the carcasses was

done by the manager and health inspector of the abattoir. The fat thickness was measured on four places on the carcass using an electronic caliper.

The following measurements were taken:

- K1(the fat thickness measured in mm on the middle of the rump)
- K2(measured on the rump 25mm from the centre of the carcass)
- L(the fat thickness measured on the loin between the 3rd and 4th lumbar (relating to the lower back joint 25mm from the middle of carcass)
- R(the fat thickness measured in mm under the first rib)



Figure 3.2 Fat thickness on the rump



Figure 3.3 Fat thickness on the rib area

3.7 Performance data

The following linear body measurements were recorded:

- Shoulder height (cm), measured vertically from the thoracic vertebrae to the ground (taken on day 1 and 35).
- Body length (BL) (cm) as measured from the sternum (manubrium) to the aitchbone (tuber ischiadicum) (taken on day 1 and 35).
- Heart girth was measured with a measuring tape around the chest just behind the front legs (taken on day 1 and 35) (Fourie *et al.*, 2002, Greyling *et al.*, 1993).

The following data was recorded during the research period:

- The initial and final mass of the animals
- The eye-muscle-measurement of the animals (EMA) (taken on day 1 and 35)
- The back fat thickness measured with an ultrasound scanner
- Average feed intake
- Average daily gain (ADG)
- Feed conversion ratio for each group (FCR)

The following measurements were taken after slaughtering all the animals in three the groups:

- Warm carcass mass
- Weight of the internal organs (heart, liver, lungs and abdominal fat)
- The fat thickness (K1,K2,L,R)
- Grading
- Dressing %

3.8 Data analyses

The analyses of variance were carried out and total pen values rather than individual animal values were used in the analysis of the effects of treatment on feed intake, live weight and live-weight gain (Forbes *et al.*, 1979).

Data was statistically analyzed using an ANOVA in Proc GLM to determine the effect of supplement light on the different parameters (SAS, 1995).

3.9 References

Bertram, J. & Phillips, A., 2004. Basic Guidelines for a Feedlot Operation. Anim. Prod. Alice, Springs. 1- 6.

Dahl, G.E., 2001. Photoperiod control improves production of dairy cows. Feedstuffs: a weekly newspaper for the feed manufacturer, feed jobber, feed broke and feed dealer. 73: 10-19.

Dahl, G.E. & Peticlerc, D., 2003. Management of photoperiod in dairy herd for improved production and health. J. Anim. Sci. 81: 11-17.

Forbes, J.M., El Shahat, A.A., Jones, R., Duncan, J.G.S., & Boaz, T.G., 1979. The effect of day length on the growth of lambs. Anim. Prod. 29: 33-42.

Forbes, J.M., 1982. Effects of lighting pattern on growth, lactation and food intake of sheep, cattle and deer. L. Prod. Sci. 9:361-374.

Fourie, P.J., Nesor, F.W.C., Olivier, J.J & Van der Westhuizen, C., 2002. Relationship between production performance and body measurements of Dorper rams. S. Afr. J. Anim. Sci. 32: 256-262.

Fourie, P.J., Maasz, D.J. & Umesiobi, D.O., 2006. The effect of supplemented light on certain production parameters of young beef bulls fed intensively. S. Afr. J. Anim. Sci. 36: 59-62.

Greyling, J.P.C., Kotze, W.F., Taylor, G.J. & Hagerdijk, W.J., 1993. Effect of an anabolic steroid on body measurements in ram lambs. Small Ruminant Research 11: 351-357.

Kendall, P.E., Auchtung, T.L., Swanson, K.S., Radcliff, R.P., Lucy, M.C., Drackley, J.K. & Dahl, G.E., 2003. Effect of photoperiod on hepatic growth hormone receptor 1A expression in steer calves. *J. Anim. Sci.* 81: 1440-1446.

Kennedy, A.D., 2001. The effect of supplemental light on growth, carcass composition and reproductive development of beef cattle. *Agri-Food Research Development Initiative.* 98-173.

Kennedy, A.D., Bergen R.D., Lawson, T.J., Small, J.A. & Veira, D.M., 2004. Effects of evening feeding and extended photoperiod on growth, feed efficiency, live animal carcass traits and plasma prolactin of beef heifers housed outdoors during two Manitoba winters. *Can. J. Anim. Sci.* 3: 491 – 500.

Peters, P.P., Chaplin, L.T., Emery, R.S. & Tucker, H.A., 1980. Growth and hormonal responses of heifers to various photoperiods. *J. Anim. Sci.* 51: 1148 – 1153.

SAS, 1995. *Statistical Analysis System user's guide.* (6th ed.). SAS Institute Inc., Raleigh, North Carolina.

Schanbacher, B.D. & Crouse, J.D., 1980. Growth and performance of growing-finishing lambs exposed to long or short photoperiods. *J. Anim. Sci.* 51: 943-948.

Shepard, H.H., Green, R.D., Golden, B.L., Hamlin, K.E., Perkins, T.L., Dilles, J.B., 1996. Genetic parameters Estimates in live Animal Ultrasonic Measures of Retail Yield Indicators on Yearling Breeding Cattle. *J. Anim. Sci.* 4:761-768.

Small, J.A., Glover, N.D., Kennedy, A.D., McCaughey, W.P. & Ward, D.R., 2003. Photoperiod effects on the development of beef heifers. *Can. J. Anim. Sci.* 83: 721-730.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

Seasonal species such as sheep, hamsters, woodchucks and reindeer demonstrate cyclical changes in food intake and body weight corresponding to the photoperiod. In seasonal animals, voluntary food intake is primary and drives the changes in feeding behaviour and consequent changes in body weight (Henry, 2003).

Light-dark cycles affect eating patterns. Sheep and heifers exposed to 16L:8D had more eating events and showed more of these events in lighted hours than animals treated with 8L:16D. Offering fresh feed also stimulated eating activity. Thus, lights on and presentation of fresh feed increased eating events (Schanbacher & Crouse, 1980; Tucker *et al.*, 1984).

4.2 Growth parameters

In the literature as reported by Tucker *et al.* (1984) daily increasing exposure to light increases feed intake when sheep or cattle are fed *ad libitum*. However, increasing feed intake is not a prerequisite for the anabolic effects of long duration exposure to light because increased growth occurs in the animals given 16hours light: 8hours dark (16L:8D) even when feed intake is restricted. The anabolic effects of increased duration photoperiods in sheep are independent of the gonads, whereas in cattle they are dependent on the gonads. Consistent increases in average daily gains of cattle in response to longer duration photoperiods have not always been achieved. These findings suggest that stimulatory effects of photoperiod on growth are not mediated primarily through increased voluntary feed intake (Tucker *et al.*, 1984). In Table 4.1 the effect of

supplemented light on the productive performance of Dorper lambs fed intensively is displayed.

Table 4.1: The effect of supplemented light on BW, Final Weight and Warm Carcass weight (mean \pm S.E.) of Dorper lambs fed intensively

Parameter	NP (n = 40)	16L:8D (n = 38)	24L:0D (n = 40)
Body weight (Start)	29.81 \pm 0.81 ^a	30.02 \pm 0.83 ^a	29.46 \pm 0.81 ^a
Body weight (End)	37.4 \pm 0.96 ^a	38.02 \pm 0.98 ^a	37.54 \pm 0.96 ^a
Warm Carcass weight	17.58 \pm 0.48 ^a	17.89 \pm 0.50 ^a	17.76 \pm 0.48 ^a

Means with different letters within the same row differ significantly: $P < 0.05$

NP – natural photoperiods; 16L:8D-16 hours light; 24L:0D-24 hours of light

In the present study the ADG of the 16L:8D and the 24L:0D groups performed slightly better than the NP group (0.22, 0.23 and 0.23 kg/animal/day) although these differences are not significant ($P > 0.05$) Table 4.1. These results concur with those of Hackett & Hillers (1979) who also recorded no differences ($P > 0.05$) among the treatments for daily gain or feed efficiency.

These results are in contrast with those of Forbes *et al.* (1979) where the growth and carcasses of lambs exposed to fixed photoperiods of either 16L:8D or 8L:16D have been studied in detail in a series of experiments at the University of Leeds. The first of these involved 72 lambs sired by Oxford or Suffolk rams out of Finn- Blackface ewes and lasted for 16 weeks starting at six months of age. There was a significant positive effect ($P < 0.01$) of day length on the weight of feed eaten during the whole experimental period by lambs which were offered concentrate feeds *ad libitum* and at the end of 16 weeks of treatment those under long days were eating 2.0 kg/day while those under short days ate 1.7kg /day

and long day length stimulated growth from the eight week on (Forbes *et al.*, 1979).

Artificial lighting in the Dorper lamb feedlot neither increased growth rate nor improved feed efficiency of feeder lambs. Hulet *et al.* (1968) found that light treatment had little or no effect on bodyweight changes. Fourie *et al.* (2006) reported that the ADG of young beef bulls receiving 24 hours light were significantly ($P < 0.05$) more elevated than the other treatment groups.

Body weights of the lambs exposed to NP, 16L:8D and 24L:0D averaged at $29.81 \pm 0.81\text{kg}$, $30.02 \pm 0.83\text{kg}$ and $29.46 \pm 0.81\text{kg}$ at the start of the trial and increased to $37.4 \pm 0.96\text{kg}$, $38.02 \pm 0.98\text{kg}$ and $37.54 \pm 0.96\text{kg}$ respectively at the end of the trial. The total weight gained per animal for the NP group was 7.59kg, 8kg for the 16L:8D group and 8.08kg for the 24L:0D group respectively.

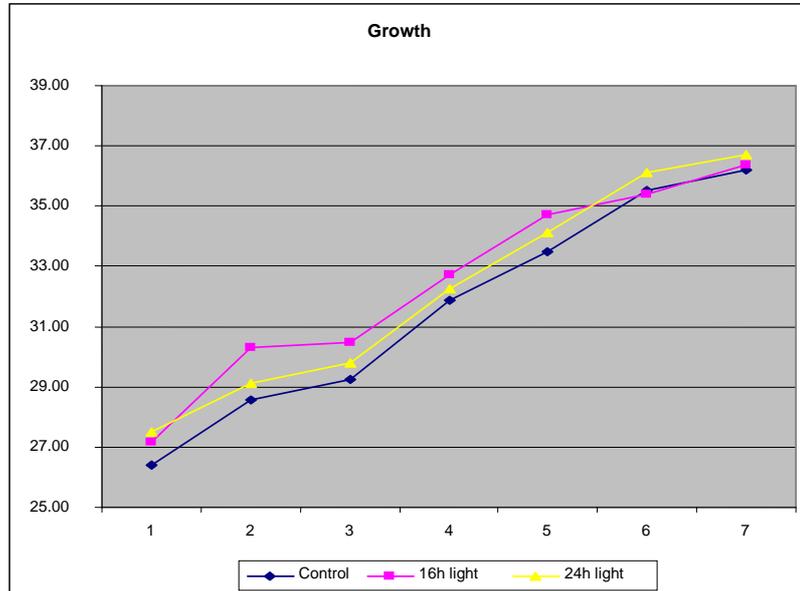


Figure 4.1: Growth curves of the three treatment groups

All three groups showed very similar growths in terms of body weight gains during all the seven day body measurements (Figure 4.1). No significant

differences could be detected between the three groups at the end of the trial. This result is in agreement with those of Hulet *et al.* (1968) where light treatment had little or no effect on bodyweight changes. Hackett & Hillers (1979) found that artificial night light did not significantly affect growth, feed efficiency or carcass characteristics on lamb performance.

Forbes *et al.* (1979) found that there was no significant affect of day length on weight gain during the first eight weeks, but animals under long day length grew significantly faster during weeks nine to sixteen. Peters *et al.* (1980) reported significant weight gain ($P < 0.02$) in Heifers exposed to 16 hours of light per day, but not by 24L:0D, but the difference did not become obvious until the ninth week of the 17 week experiment.

Phillips (1997) reported that by extending the photoperiod for cattle in winter, there were no affects over the entire experiment on the growth rate or feed intake of either steers or heifers. Enright, *et al.* (1995) reported as well that providing supplementary light to pre/peripubertal and postpubertal heifers did not significantly stimulate BW gain. This is in agreement with the findings of Zinn *et al.* (1989) that photoperiod does not alter BW gain in carcass composition of beef steers.

The total FCR of the different groups in this study were 7.18:1 (NP), 7.15:1 (16L:8D) and 6.86:1 (24L:0D) respectively. This showed that the 24L:0D group had a better FCR than the NP and 16L:8D group. When looked at; the ADG, 16L:8D and 24L:0D performed better than NP (0.22 ± 0 , 0.24 ± 0 and 0.24 ± 0). Individual FCR could not be determined as the performance of each group as a whole was determined.

Feed efficiency was significantly affected by photoperiod in the study of Forbes *et al.* (1979) and in the study of Schanbacher & Crouse (1980). Hackett & Hillers (1979) reported that although lambs in the artificial treatment groups gained

slightly faster, there were no differences ($P > .05$) among the treatments for daily gain or feed efficiency.

Phillips *et al.* (1997) found that there was no treatment affect over the whole experiment on feed conversion ratio for either steers or heifers which is in contrast of the findings of Peters *et al.* (1980) when heifers were provided with 16L:8D their ADG were 11% to 17 % higher than the gain of animals exposed to continuous lighting or natural photoperiod. Feed to gain ratios were lowest for heifers given 16L:8D and were more efficient in converting feed into weight gain.

4.3 A comparison of wethers and male lambs with regard to growth parameters

In Table 4.2 a comparison between the wethers and male lambs are made.

Table 4.2: The differences between ADG, Total weight gained (TWG), Rump Fat gained (RFG), EMAG (gained) and Heart girth gained (HGG)

Parameter	Wethers	Rams
ADG (kg/day)	0.2 ± 0.08^a	0.24 ± 0.09^b
RFG (mm)	1.11 ± 0.85^a	1.3 ± 1.17^a
EMAG (cm ²)	6.71 ± 2.72^a	6.32 ± 1.78^a
HGG (cm)	6.29 ± 2.61^a	6.58 ± 3.05^a

Means with different letters within the same row differ significantly: $P < 0.05$

The results presented in Table 4.2 show that ram lambs ($0.24\text{kg/day} \pm 0.08$) grew more rapidly than wether lambs ($0.24\text{kg/day} \pm 0.09$). This is in agreement with the results in the study of Schanbacher & Crouse (1980) where the rams grew more rapidly and efficiently than wethers. However the feed efficiency of

the ram lambs could not be determined in the present study because the animals were group fed.

Table 4.3: The effect of supplemented light on ADG (mean \pm S.E.) for different parameters

Parameter	NP (n = 40)	16L: 8D (n = 38)	24L: 0D (n = 40)
ADG for Rams (kg/day)	0.22 \pm 0.11 ^a	0.33 \pm 0.10 ^b	0.24 \pm 0.08 ^a
ADG for Wethers (kg/day)	0.22 \pm 0.05 ^a	0.17 \pm 0.10 ^a	0.22 \pm 0.09 ^a
ADG for Rams & Wethers (kg/day)	0.22 \pm 0.09 ^a	0.26 \pm 0.13 ^a	0.23 \pm 0.08 ^a

Means with different letters within the same row differ significantly: $P < 0.05$

NP – natural photoperiods; 16L:8D-16 hours light; 24L:0D-24 hours of light

Data presented in Table 4.3 pointed out that the ADG of ram lambs of the (16L:8D) group (0.33kg \pm 0.10) performed significantly better ($P < 0.01$) than the NP (0.22kg \pm 0.11) and (24L:0D) group (0.24kg \pm 0.08). When the ADG of the (24L:0D) group was compared with the NP group, no significant difference was detected. Hackett & Hillers (1979) reported no effects from giving lambs artificial light throughout the night. Peters *et al.* (1980) and Tucker & Ringer (1982) confirmed that the rate of body weight gain of Holstein heifers in natural day lengths (NP) were not different from those in continuous lighting (24L:0D) and that a period of darkness was necessary to achieve weight gain when Holstein heifers were supplemented with light.

The results of the present study is also in agreement with the findings of Schanbacher & Crouse (1980) who stated that the lambs under long photoperiods (16L:8D) promoted more rapid gains than short photoperiods and improved feed efficiency. The positive effects of sex and photoperiod treatment on laboratory or controlled environments were evident in carcass weight.

Performance and carcass data showed that both the photoperiod and sex of lamb affected growth rate ($P < 0.01$), feed efficiency ($P < 0.05$) and yield ($P < 0.10$). A sex by photoperiod interaction was not observed for any of the traits measured. Average daily gain was: rams (16L:8D) 410 g/day : (8L:16D) 340 g/day and wethers (16L:8D) 345 g/day : (8L:16D) 300 g/day respectively. Feed efficiency (feed/gain) was rams (16L:8D) 4.3:1; (8L:16D) 4.5:1; wethers (16L:8D) 4.6:1; (8L:16D) 4.8:1. Carcass weight, was affected by photoperiod ($P < 0.01$) and sex of lamb ($P < 0.05$); both rams and wethers exposed to long photoperiods had the heaviest carcasses. Ram carcasses were leaner; had better yield grades and were heavier than wether carcasses; both ram and wether carcasses graded Choice (Schanbacher & Crouse 1980). It must be noted that these lambs, aged 10 weeks weighing approximately 24 kg, were exposed to photoperiod of 16L:8D and 8L:16D for 12 weeks and that a relatively high intensity of artificial light (800 – 900 lux, at eye level) was used in this experiment, whereas most other researchers have used intensities of around 100 lux.

4.4 Carcass parameters

The results are presented in Table 4.4.

Table 4.4: The effect of supplemented light on certain carcass parameters of (mean \pm S.E.) of Dorper lambs measured in the abattoir

Parameter	NP (n = 40)	16L: 8D (n = 38)	24L: 0D (n = 40)
Grading (0-6)	1.82 \pm 6.36 ^a	1.72 \pm 6.53 ^a	1.84 \pm 6.36 ^a
Conformation (1-5)	4.02 \pm 0.12 ^a	4.43 \pm 0.13 ^b	4.17 \pm 0.12 ^b
Rump Fat (start)(mm)	3.81 \pm 8.28 ^a	3.64 \pm 8.49 ^b	3.39 \pm 8.28 ^c
Corrected EMA (start)(cm ²)	10.01 \pm 0.20 ^a	10.38 \pm 0.21 ^a	9.97 \pm 0.20 ^a
Rump Fat (end)(mm)	4.67 \pm 0.14 ^a	4.78 \pm 0.14 ^a	5.05 \pm 14 ^a
Corrected EMA (end)(cm ²)	15.67 \pm 0.31 ^a	17.58 \pm 0.32 ^b	16.59 \pm 0.31 ^c
Fat Thickness K1(mm)	4.4 \pm 0.38 ^a	4.85 \pm 0.39 ^a	4.87 \pm 0.38 ^a
Fat Thickness K2(mm)	4.57 \pm 0.78 ^a	3.49 \pm 0.8 ^a	3.55 \pm 0.78 ^a
Fat Thickness L(mm)	2.48 \pm 0.16 ^a	2.78 \pm 0.17 ^a	2.75 \pm 0.16 ^a
Fat Thickness R(mm)	1.32 \pm 8.93 ^a	1.49 \pm 9.16 ^a	1.57 \pm 8.93 ^a
Heart weight (g)	160.65 \pm 3.16 ^a	155.76 \pm 3.24 ^a	155.3 \pm 3.16 ^a
Liver weight (g)	712.28 \pm 24.5 ^a	725.37 \pm 25.14 ^a	698.45 \pm 24.5 ^a
Weight of Lungs (g)	770.08 \pm 20.91 ^a	739.18 \pm 21.45 ^a	771.5 \pm 20.91 ^a
Abdominal Fat (g)	217.58 \pm 21.1 ^a	267.08 \pm 21.65 ^a	264.83 \pm 21.1 ^a

Means with different letters within the same row differ significantly: $P < 0.05$

NP – natural photoperiods; 16L:8D- 16 hours light; 24L:0D- 24 hours of light

Natural photoperiods differed significantly from 16L:8D and 24L:0D when looking at the conformation of the different groups. All three groups differed significantly from each other when looking at the rump fat start and corrected EMA end. The dressing percentage of the lambs in NP group was 45.16%, 45.70% for the 16L:8D group and 45.8% for the 24L:0D group.

The fat measurements taken on the carcasses of the animals did not differ significantly ($P < 0.05$). There were no significant differences ($P > 0.05$) in the weight of the heart, liver, lungs and abdominal fat between the groups.

Schanbacher & Crouse, (1980) reported that although the carcass traits of back fat thickness, kidney and pelvic fat, quality grade and yield grade were significantly affected by sex, these traits were not influenced by the photoperiod exposure.

In Forbes *et al.* (1979-experiment 2) the cold carcass weight was only 1.1kg greater in the 16L:8D lambs, which was not significantly heavier than the carcasses from the short day length animals. In addition to live weight gains, 16L:8D increased the carcass weight of sheep (Forbes *et al.*, 1979,1982; Schanbacher & Crouse, 1980, 1982). In a few experiments, the carcass of sheep exposed to 16L:8D were leaner than those of sheep given 9L:16D (Forbes *et al.*,1979; Schanbacher *et al.*, 1982). Forbes *et al.* (1979) reported that 16L:8D exposures increased muscle mass in the carcass and did not change the fat percentage between the 11th to 13th rib section or in the fat depots .

4.4 Body measurements

The effect of light supplementation on body measurements are presented in table 4.5.

Table 4.5: The effect of supplemented light on certain body measurements (mean \pm S.E.) of Dorper lambs fed intensively

Parameter	NP (n = 40)	16L: 8D (n = 38)	24L: 0D (n = 40)
Body length start (cm)	62.18 \pm 0.58 ^a	62.81 \pm 0.59 ^a	63.8 \pm 0.58 ^b
Shoulder height start (cm)	55.18 \pm 0.42 ^a	53.97 \pm 0.43 ^b	54.83 \pm 0.42 ^b
Heart girth start (cm)	69.3 \pm 0.81 ^a	70.45 \pm 0.83 ^a	70.65 \pm 0.81 ^a
Body length end (cm)	66.15 \pm 0.53 ^a	65.87 \pm 0.55 ^a	66.55 \pm 0.53 ^a
Shoulder height end (cm)	58.82 \pm 0.41 ^a	58.92 \pm 0.42 ^a	59.18 \pm 0.41 ^a
Heart girth end (cm)	76.33 \pm 0.78 ^a	77.34 \pm 0.80 ^b	76.13 \pm 0.78 ^b

Means with different letters within the same row differ significantly: $P < 0.05$

NP – natural photoperiods; 16L:8D- 16 hours light; 24L:0D- 24 hours of light

Between NP and 16L:8D the difference in body length was not significant, but between 16L:8D and 24L:0D the difference was significant. According to Forbes (1982) carcasses from sheep under 16L:8D were significantly larger and less fatty than those under 8L:16D. When looked at the shoulder height start a significant difference could be seen between NP and 16L:8D. This was also the case with the heart girth end which cannot be explained. There was an 82% correlation between the WCW and the BL. The correlation between the WCW and SH was 62% and a 91% for the HG. This meant that HG had a bigger influence on the WCW than the BL and SH.

There were non-significant differences in body length, shoulder height and heart girth between the treatment groups. Heart girth (HG) is generally accepted as the most reliable indicator (Benyi, 1997) of growth (body weight). The highest correlation of 0.92 ($P < 0.0001$) was found between HG and BW. This correlation is even higher than the correlation between body length (BL) and body weight, which had a correlation of 0.81 ($P < 0.0001$). Fourie *et al.* (2002) reported correlations of 0.80 ($P < 0.001$) between HG and BW and a correlation of 0.76 ($P < 0.001$) between BL and BW in Dorper rams.

4.6 Hair type vs. wool type in Dorper sheep

Animals within the Dorper breed are classified into different types according to coat cover, conformation and fat distribution. Snyman (2002) reported that hair type lambs had a better conformation than wool type lambs for chest width and depth, protrusion of the chest between the front legs, shoulders, hind quarters and width of the rump. Wool type lambs had a higher body height and length of hind leg, as well as better hocks and less sloped rumps, compared to hair type lambs. There was no difference in general conformation of the head, width of hind leg, body length, body depth, front or hind pasterns or top line between lambs of the hair and wool types. These characteristics may have contributed to blockier hair type lambs with shorter legs, compared to the leggier appearance of the wool type lambs (Snyman, 2002).

Table 4.6: The effect coat type on certain parameters (mean \pm S.E.) of Dorper lambs.

Parameter	Kemp (n = 28)	Mixed (n = 25)	Wool (n = 65)
Total weight gained (kg)	1.74 \pm 0.81 ^a	1.42 \pm 1.22 ^a	1.75 \pm 1.07 ^a
ADG per animal (kg/day)	0.2 \pm 0.09 ^a	0.24 \pm 0.1 ^a	0.23 \pm 0.08 ^a
Dressing %	46.17 \pm 2.51 ^a	45.34 \pm 2.73 ^a	45.64 \pm 2.13 ^a

Means with different letters within the same row differ significantly: $P < 0.05$

Hair type Dorpers appeared smaller, compared to their woolly counterparts. Testis circumference of hair type ram lambs was larger than that for the wool type ram lambs (28.1 vs 27.6). There was no difference in the age when hair and wool type lambs reached slaughter weight. The dressing percentage of wool type lambs was higher than hair type lambs in the study of Snyman (2002). There was no difference in grading (NP) 1.82 \pm 6.36^a; (6L:8D) 1.72 \pm 6.53^a; (24L:0D) 1.84 \pm 6.36^a between hair and wool lamb carcasses (Snyman, 2002).

In terms of the economically important reproduction and growth traits, there were no differences between hair and wool types of Dorper sheep (Snyman, 2002). In Table 4.6 the effect of coat type of Dorper lambs are presented.

The results in this study (Table 4.6) showed that there were no significant differences ($P < 0.05$) between the lambs with a coating of kemp, mixture between kemp and wool, and wool. This is in agreement with the results found in the study of Snyman, (2002).

4.7 References

Benyi, K., 1997. Estimation of live weight from chest girth in pure and crossbred West African goats. *Trop. Anim. Health Prod.* 29: 124-128.

Enright, W.J., Zinn, S.A., Reynolds, V.S. & Roche, J.F., 1995. The effect of supplementary light on winter performance of prepubertal and post pubertal Friesian Heifers. *Irish J. Agric. and Food Research.* 34: 107 -113.

Forbes, J.M., El Shahat, A.A., Jones, R., Duncan, J.G.S., & Boaz, T.G., 1979. The effect of day length on the growth of lambs. *Animal production.* 29: 33-42.

Forbes, J.M., 1982. Effects of lighting pattern on growth, lactation and food intake of sheep, cattle and deer. *L. Prod. Sci.* 9:361-374.

Fourie, P.J., Maasz, D.J. & Umesiobi, D.O., 2006. The effect of supplementary light on certain productive parameters of young beef bulls fed intensively. *S. Afr. J. Anim. Sci.* 36 : 59 – 62.

Fourie, P.J., Neser, F.W.C., Olivier, J.J & Van der Westhuizen, C., 2002. Relationship between production performance and body measurements of Dorper rams. *S. Afr. J. Anim. Sci.* 32: 256-262.

Hackett, M.R. & Hillers, J.K., 1979. Effects of artificial lightning on feeder lamb performance. *J. Anim. Sci.* 49: 1- 4.

Henry, B.A., 2003. Young investigator perspectives. Links between the appetite regulating systems and the neuroendocrine hypothalamus: Lessons from the Sheep., *Journal of Neuroendocrinology.* 15: 697 – 709.

Hulet, C.V., Price, D.A. & Foote, W.C., 1968. Effects of variation in light, month of year and nutrient intake on reproductive phenomena in ewes during the breeding season. *J. Anim. Sci.* 27: 684-690.

Peters, R.R., Chapin, L.T., Emery, R.S. & Tucker, H.A., 1980. Growth and hormonal response of heifers to various photoperiods. *J. Anim. Sci.* 51: 1150-1153.

Phillips, C.J.C., Johnson, P.N. & Arab T.M., 1997. The effect of supplementary light during winter on the growth, body composition and behaviour of steers and heifers. *British J. Anim. Sci.* 65: 173 -181.

Schanbacher, B.D. & Crouse, J.D., 1980. Growth and performance of growing-finishing lambs exposed to long or short photoperiods. *J. Anim. Sci.* 51: 943-948.

Schanbacher, B.D. Hahn, G.L. & Nienaber, J.A., 1982. Effects of contrasting photoperiods and temperatures on performance traits of confinement-reared ewe lambs. *J. Anim. Sci.* 55: 620- 626.

Snyman, M.A. & Olivier, W.J., 2002. Productive performance of hair and wool type Dorper sheep under extensive conditions. *Small Ruminant Research.* 45: 17-23.

Tucker, H. A. & Ringer, R.K., 1982. Controlled photoperiodic environments for food animals. *American Association for the advancement of Science.* 216: 1381-1386.

Tucker, H.A., Peticlere , D. & Zinn, S.A., 1984. The influence of photoperiod on body weight gain, body composition, nutrient intake and hormone secretion. *J. Anim. Sci.* 59: 1610-1620.

Zinn, S.A., Chaplin, L.T., Enright, W.J. & Tucker, H.A., 1989. Failure of photoperiod to alter body growth and carcass composition in beef steers. *J. Anim. Sci.* 67: 1249 – 1257.

CHAPTER 5

GENERAL CONCLUSION AND RECOMMENDATIONS

Contradictory results were found in studies that researched the effect of supplemented light on feedlot lambs. It is important to note that the significant positive results in studies of Forbes *et al.* (1979); Forbes (1982) and Schanbacher & Crouse (1980) were done under closely controlled and laboratory conditions, which involved the exclusion of natural light to achieve controlled day-lengths. This is impractical under commercial conditions and the positive effect was noticed from the eighth week of the 16 and 12 week trails.

Sheep, cattle and deer show significant increases in growth with long days in some experiments, particularly those in which the comparison is between fixed 16 hours and 8 hours days. Hackett & Hillers (1979) reported no effects from giving lambs artificial light throughout the night and Peters *et al.* (1980) found that the live weight gains of heifers exposed to 24L:0D were not different from those of similar animals under natural day lengths and that a period of darkness was necessary to achieve weight gain when Holstein heifers were supplemented with light. Tucker & Ringer (1982) confirmed that continuous lighting did not increase the rate of body weight gain. It is possible that continuous light is detrimental to weight gain in ruminants because Hulet *et al.* (1968) found that live weight increased more slowly in mature ewes kept in continuous light, compared with those kept in natural day length, continuous dark, or a 2L:2D intermittent lighting schedule.

Hackett & Hillers (1979) found that artificial lighting in the lamb feedlot neither increased growth rate nor improved feed efficiency of feeder lambs and neither did Hulet *et al.* (1968) who followed the live weights of ewes. The absence of a stimulatory effect of supplemental lighting on lamb performance in the study of Hackett & Hillers (1979) where feeder lambs were kept in an open environment may be attributable to some unmonitored environmental factor(s) that interacted

negatively with the photoperiod. Dorper lambs in this trial were housed in open pens and weather and environmental factors could have influenced the results. However, it is a perfect simulation of feedlots on commercial farms.

Forbes *et al.* (1979); Forbes (1982) and Schanbacher & Crouse (1980) reported the positive effect of supplement light from the eighth week of the 16 and 12 week trials respectively. However, the Dorper lambs in this study were ready for the meat market at an age of four and a half months and could not stay for such a long period in a feedlot.

The results emanating from this study suggest that supplemented light does not have a significant affect on growth, feed efficiency, fat deposition, dressing%, body dimensions and the weight of the internal organs of Dorper lambs when the data of the whole group (rams and wethers) was analysed. However, there was a significant difference ($P < 0.05$) in the ADG of the ram lambs in the (16L:8D) group compared to the NP and the (24L:0D) group. It is therefore recommended that farmers/breeders utilize the advantages of supplemented light when feeding ram lambs. Further research needs to be done on this topic, including different breeds of sheep using non castrated animals as testosterone secretion may have had an influence on lean growth.

It is important that the growth–stimulating effect of long day length is confirmed in under a wide range of conditions. The extension of natural days with artificial light under commercial conditions has not shown any consistent benefit under these conditions.

References:

Forbes. J.M., 1982. Effects of lighting pattern on growth, lactation and food intake of sheep, cattle and deer. *L. Prod. Sci.* 9:361-374.

Forbes, J.M., El Shahat, A.A., Jones, R., Duncan, J.G.S., & Boaz, T.G., 1979. The effect of day length on the growth of lambs. *Anim. Prod.* 29: 33-42.

Hackett. M.R. & Hillers, J.K., 1979. Effects of artificial lightning on feeder lamb performance. *J. Anim. Sci.* 49: 1-4.

Hulet, C.V., Price, D.A. & Foote, W.C., 1968. Effects of variation in light, month of year and nutrient intake on reproductive phenomena in ewes during the breeding season. *J. Anim. Sci.* 27: 684-690.

Peters, R.R., Chapin, L.T., Emery, R.S. & Tucker, H.A., 1980. Growth and hormonal response of heifers to various photoperiods. *J. Anim. Sci.* 51: 1150-1153.

Schanbacher, B.D. & Crouse, J.D., 1980. Growth and performance of growing-finishing lambs exposed to long or short photoperiods. *J. Animal Sci.* 51: 943-948.

Tucker, H. A. & Ringer, R.K., 1982. Controlled photoperiodic environments for food animals. *American Association for the advancement of Science.* 216: 1381-1386.

ADDENDUM A

The influence of supplementary light on Dorper lambs fed intensively

P.J. Fourie[#], P.J.A. Vos and S.S. Abiola

Department of Agriculture, Central University of Technology, Free State, Private Bag X20539,
Bloemfontein 9300, South Africa

Abstract

The objective of this trial was to quantify the differences in average daily gain (ADG), back fat thickness (BFT), eye muscle area (EMA), fat thickness (FT) on different body parts, the feed conversion ratio (FCR), body measurements and the weight of internal organs of Dorper lambs exposed to supplemented light. For this study one hundred and twenty Dorper lambs (115 ± 10 days old) weighing (29.76 ± 5.01kg) were used. The lambs were randomly divided into three homogeneous groups (20 castrated and 20 intact males). The three groups were then exposed to different levels of supplemented light at 145 lux (16h, 24h and normal photoperiod). The animals were fed *ad libitum* with pellets containing 9.5 MJ ME/kg DM and 12% CP in open pens. The animals were weighed every 7 days while ultrasound scanning of the EMA and the BFT was done at the beginning and the end of the 35 day trial. The ADG, FCR and feed intake (FI) were calculated at the end of the trial. Linear body measurements including shoulder height, body length and heart girth were taken at day 1 and day 35 respectively. All the animals were slaughtered at the end of the trial. The carcasses were then weighed, graded and the FT was measured with a caliper. It was concluded that there are no significant differences between treatments in terms of body measurements, ultrasound scanning, ADG and FCR.

Keywords: Light supplementation, photoperiod, Dorper lambs, intensive feeding

[#] Corresponding author. E-mail address: pfourie@cut.ac.za

Introduction

There are indications that the demand for mutton and lamb will soon exceed supply should the current mainly extensive, production systems be retained (Louw & Read, 1991). The question arises whether the feedlotting of sheep should be expanded. Intensive feeding involves the withdrawal of animals from veld (natural pasture) and providing them with a higher level of nutrition in a feedlot and could include the strategic use of cultivated pastures. The intensive feeding and fattening of sheep is a highly specialized business which requires a high level of management ability to ensure success (Louw & Read, 1991). A sound knowledge of nutrition, diseases and market prices is essential for such an undertaking to be successful. In any intensive production system factors such as management, housing and feeding are of utmost importance (Louw & Read, 1991; Bertram & Phillips, 2004).

A factor that may have a huge impact on the performance of animals under feedlot conditions in the near future is light manipulation (Fourie *et al.*, 2006). Photoperiod (the period of daily illumination an organism receives) management is used by many dairy producers to increase profits. Photoperiod is defined as the duration of light an animal is exposed to in a 24-hour period (Dahl, 2001; Small *et al.*, 2003). Animals use photoperiod to track the length of the day. A long-day photoperiod is considered exposure to 16-18 hours of light associated with a 6-8 hours period of darkness. In contrast, a short-day photoperiod is usually 8 hours of light and 16 hours of darkness (Dahl, 2001). Small *et al.* (2003) and Kennedy *et al.* (2004) conducted studies on the effect of supplemented light on beef heifers and significant improvements were found in terms of growth and carcass composition. Long days have consistently been shown to improve

milk yield during established lactation (Dahl *et al.*, 2000). In addition, photoperiod management can be used to improve heifer growth and maximize accretion of lean tissue, including mammary parenchyma (Dahl & Peticlerc, 2003).

The Dorper is generally recognized as one of the most popular mutton breeds in South Africa. It is well adapted to variety of veld types and climates, and is farmed over wide geographical range in this country (Nel, 1993). The Dorper is a medium maturing sheep that will reach optimum slaughter weight at 34-38kg (Maree & Casey, 1993).

The questions that arise are whether light manipulation will affect the feedlot performance of Dorper lambs. The objective of this study was therefore to evaluate the effect of different photoperiods on the ADG, average feed intake (FI), back fat thickness (BFT), eye muscle area (EMA), dressing% and feed conversion ratio (FCR), the weight of the internal organs as well as to determine whether light supplementation has any effect on body dimensions of animals exposed to varying day length.

Materials and methods

One hundred and twenty Dorper lambs, (115 ± 10 days) of age weighing (29.76 ± 0.82 kg) were used. All the animals were divided into 3 homogeneous groups (40 animals/group blocked by weight and age) of which 20 were intact males and 20 castrated males. The lambs were born and raised on the natural veld. During the trial period, the animals were housed in open pens and weighed every 7 days. After adaptation the lambs were fed *ad lib* on a diet containing 12% CP and 9.5MJ ME/kg/DM for 35 days. The artificial source of light comprised high pressure sodium lights giving a light intensity of 145 lux measured at eye level, as measured with a digital illumination meter (INS DX 200). At the end of the trial all the lambs were slaughtered. The following data were recorded: Initial and final weight (FW), linear body measurements, subcutaneous fat depth between the 12th and 13th rib (BFT), *longissimus dorsi* (EMA) (taken on day 1 and 35), measured with a PIE Medical Falco 100 ultrasound scanner as well average feed intake per group (FI), average daily gain (ADG) and feed conversion ratio (FCR) for each group. The following measurements were taken after slaughtering the animals in all the groups: warm carcass weight (WCW), weight of the internal organs (heart, liver, lungs and abdominal fat), rump fat, rib fat, grading and dressing %. Linear body measurements including shoulder height, body length and heart girth were taken at day 1 and day 35 respectively.

The following treatments were applied:

Group 1: The lights were manually switched of at dawn, and switched on half an hour before sunset, so that the animals did not experience natural sunset before the beginning of supplemented light. This group was subjected to 24 hours light. No clout cover was recorded during the trial.

Group 2: The lights were switched on by means of an automatic timer and the duration was adjusted twice a week as the daylight decreased in order to expose the lambs to 16 hours light and 8 hours darkness/day.

Group 3: This group served as the control group and only received natural photoperiods (NP). All the pens were far away from each other, preventing artificial light to reflect on this group and have an influence on the natural light conditions.

Data was statistically analysed using a one way ANOVA in Proc GLM to determine the effect of supplemented light on the different parameters.

Results and Discussions

For ADG, the 16L:8D and the 24L:0D group performed slightly better than the NP group (0.22, 0.23 and 0.23 kg/animal/day) although these differences are not significant ($P>0.05$) Table 1. These results concur with those of Hackett & Hillers (1979) who also recorded no differences ($P>0.05$) between the treatments for daily gain or efficiency of feed utilization. Artificial lighting in the lamb feedlot neither increased growth rate nor improved feed efficiency of feeder lambs.

Hulet *et al.* (1968) concluded that light treatment had little or no effect on bodyweight changes. Fourie *et al.* (2006) reported that the ADG of young beef bulls subjected to 24h light were significantly ($P < 0.05$) higher than that of bulls subjected to 16L:8D and normal conditions. Body weights of the lambs exposed to NP, 16L: 8D and 24L: 0D averaged at 29.81 ± 0.81 , 30.02 ± 0.83 and 29.46 ± 0.81 kg at the start of the trial and increased to 37.4 ± 0.96 , 38.02 ± 0.98 and 37.54 ± 0.96 kg respectively at the end of the trial. The total weight gained for the NP group was 7.59kg, 8kg for the 16L: 8D group and 8.08kg for the 24L: 0D group. There was a 82% correlation between the WCW and the body length (BL). The correlation between WCW and shoulder height (SH) was 62% and 91% between heart girth (HG) and WCW. This indicates that HG had a bigger influence on the WCW than the BL and SH.

Table 1 The effect of supplemented light on body weight, final body weight, warm carcass weight and average daily gain (mean \pm s.e.) of Dorper lambs fed intensively

Parameter	NP (n = 40)	16L: 8D (n = 38)	24L: 0D (n = 40)
Body weight start (kg)	29.81 ± 0.81^a	30.02 ± 0.83^a	29.46 ± 0.81^a
Final body weight (kg)	37.4 ± 0.96^a	38.02 ± 0.98^a	37.54 ± 0.96^a
Warm carcass weight (kg)	17.58 ± 0.48^a	17.89 ± 0.50^a	17.76 ± 0.48^a
Average daily gain (kg)	0.22 ± 0.01^a	0.23 ± 0.01^a	0.23 ± 0.01^a

Means with different letters within the same row differ significantly: $P < 0.05$

NP – natural photoperiods; 16L:8:D- 16 hours light; 24:L:0D- 24 hours of light

The FCR of the different groups were 7.18 (NP), 7.15 (16L:8D) and 6.86 (24L:0D) respectively. The dressing percentage of the lambs in NP group was 45.16%, 45.70% for the 16L:8D group and 45.8% for the 24L:0D group.

Table 2 The effect of supplemented light on grading, carcass conformation, fat thickness on rib, heart weight, liver weight, weight of lungs, abdominal fat, corrected eye muscle area at start, rump fat and corrected eye muscle area (mean \pm s.e.) of Dorper lambs fed intensively

Parameter	NP (n = 40)	16L: 8D (n = 38)	24L: 0D (n = 40)
Grading (0-6)	1.82 ± 6.36^a	1.72 ± 6.53^a	1.84 ± 6.36^a
Carcass conformation (1-5)	4.02 ± 0.12^a	4.43 ± 0.13^b	4.17 ± 0.12^b
Fat thickness rib (mm)	1.32 ± 8.93^a	1.49 ± 9.16^a	1.57 ± 8.93^a
Heart weight (g)	160.65 ± 3.16^a	155.76 ± 3.24^a	155.3 ± 3.16^a
Liver weight (g)	712.28 ± 24.5^a	725.37 ± 25.14^a	698.45 ± 24.5^a
Weight of lungs (g)	770.08 ± 20.91^a	739.18 ± 21.45^a	771.5 ± 20.91^a
Abdominal fat (g)	217.58 ± 21.1^a	267.08 ± 21.65^a	264.83 ± 21.1^a

Corrected eye muscle area (start) (cm ²)	10.01 ± 0.20 ^a	10.38 ± 0.21 ^a	9.97 ± 0.20 ^a
Rump fat (mm)	4.67 ± 0.14 ^a	4.78 ± 0.14 ^a	5.05 ± 14 ^a
Corrected eye muscle area (cm ²)	15.67 ± 0.31 ^a	17.58 ± 0.32 ^b	16.59 ± 0.31 ^c

Means with different letters within the same row differ significantly: $P < 0.05$.

NP – natural photoperiods; 16L:8:D- 16 hours light; 24:L:0D- 24 hours of light

The fat measurements of carcasses from the different treatments did not differ significantly ($P < 0.05$). There were no significant differences ($P < 0.05$) in the weight of the heart, liver, lungs and abdominal fat between the groups. Schanbacher, & Crouse, 1980 reported that although the carcass traits of backfat thickness, kidney and pelvic fat, quality grade and yield grade were significantly affected by gender, these traits were not influenced by photoperiod. Corrected EMA differed significantly ($P < 0.05$) between the 16L:8:D light and 24:L:0D treatment groups, with the latter having the largest EMA.

Body length, shoulder height and heart girth did not differ significantly between the treatment groups. Heart girth (HG) is generally accepted as the most reliable indicator (Benyi, 1997) of growth (body weight). The following positive correlations were recorded: The highest correlation of 0.92 ($P < 0.0001$) was found between HG and FW. This correlation is even higher than the correlation between body length (BL) and body weight, which had a correlation of 0.81 ($P < 0.0001$). Fourie *et al.* (2002) reported correlations of 0.80 ($P < 0.001$) between HG and BW and a correlation of 0.76 ($P < 0.001$) between BL and BW in Dorper rams.

Conclusions

It is concluded that supplemented light has no significant effect on growth, feed efficiency, fat deposition, dressing%, body dimensions or the weight of the internal organs of Dorper lambs.

References

- Benyi, K., 1997. Estimation of live weight from chest girth in pure and crossbred West African goats. *Trop. Anim. Health Prod.* 29: 124-128.
- Bertram, J. & Phillips, A. 2004. Basic Guidelines for a Feetlot Operation. Anim. Prod. Alice, Springs. 1- 6.
- Dahl, G.E., Buchanan, B.A., & Tucker, H.A., 2000. Photoperiodic effects on dairy cattle: A review. *J. Dairy Sci.* 83, 885-893.
- Dahl, G.E. 2001. Photoperiod control improves production of dairy cows. *Feedstuffs: a weekly newspaper for the feed manufacturer, feed jobber, feed broke and feed dealer.* 73, 10-19.
- Dahl, G.E. & Peticlerc, D. 2003. Management of photoperiod in dairy herd for improved production and health. *J. Anim. Sci.* 81, 11-17.
- Fourie, P.J., Nesor, F.W.C., Olivier, J.J & Van der Westhuizen, C. 2002. Relationship between production performance and body measurements of Dorper rams. *S. Afr. J. Anim. Sci.* 32: 256-262.
- Fourie, P.J., Maasz, D.J. & Umesiobi, D.O. 2006. The effect of supplemented light on certain production parameters of young beef bulls fed intensively. *S. Afr. J. Anim. Sci.* 36: 59-62.
- Hackett, M.R. & Hillers, J.K. 1979. Effects of artificial lightning on feeder lamb performance. *J. Anim. Sci.* 49, 1- 4.
- Hulet, C.V., Price, D.A. & Foote, W.C. 1968. Effects of variation in light, month of year and nutrient intake on reproductive phenomena in ewes during the breeding season. *J. Anim. Sci.* 27, 684-690.
- Kennedy, A.D., Bergen R.D., Lawson, T.J., Small, J.A. & Veira, D.M. 2004. Effects of evening feeding and extended photoperiod on growth, feed efficiency, live animal carcass traits and

- plasma prolactin of beef heifers housed outdoors during two Manitoba winters. *Can. J. Anim. Sci.* 3, 491 – 500.
- Louw. C.J. & Read, M. 1991. Intensive feeding and finishing of lambs and culls. *Natal Sheep 5.5* Department of Agricultural Development . Natal region Pietermaritzburg :1- 4.
- Maree, C & Casey, N.H. 1993. *Livestock Production Systems principles and practice*. Brooklyn: Agri-Development Foundation.
- Nel, J.A., 1993. History of the Dorper (in Afrikaans). Dorper Sheep Breeder's Society of South Africa, PO Box 26, Middelburg, C.P. 5900 South Africa.
- Schanbacher, B.D. & Crouse, J.D. 1980. Growth and performance of growing-finishing lambs exposed to long or short photoperiods. *J.Anim. Sci.* 51, 943-948.
- Small, J.A., Glover, N.D., Kennedy, A.D., McCaughey, W.P. & Ward, D.R. 2003. Photoperiod effects on the development of beef heifers. *Can. J. Anim. Sci.* 83, 721-730.