AN ABSTRACT OF THE THESIS OF

Debora Ann Collins for the degree of Master of Science

in Animal Science presented on June 18, 1982

Title: Effects of sire breed on growth, feed efficiency, and carcass traits of crossbred lambs slaughtered at three weights

Redacted for Privacy

Abstract approved: ______________________________

Dr. David L. Thomas

This study examined the effects of sire breed and weight on the performance of 117 crossbred wether lambs born at the Oregon State University Agricultural Experiment Station, Corvallis. Lambs were produced by mating Clun Forest, Polypay, Dorset, Border Leicester, and Suffolk sires to Columbia-type ewes. After weaning at approximately 90 days of age (34 kg), the lambs were separated into two groups for experimentation, 1) 30 individually fed, and 2) 87 group fed lambs. Both groups were fed similar diets. Individually fed lambs were slaughtered at 57 kg live weight. Group fed lambs were randomly assigned live weights of 43, 50, and 57 kg. Average daily gain (ADG) and carcass data were collected from both groups; feed per unit of gain (F/G) was also collected from the individually fed group. Lambs produced by the five sire breeds were similar for ADG and F/G. Differences were found among sire breeds for some carcass traits: loin-eye area ($P<.05$), leg conformation score ($P<.05$), flank streaking ($P<.10$), and USDA quality grade ($P<.10$). Weight increase greatly affected ADG ($P<.05$), F/G ($P<.01$), and carcass traits ($P<.01$). ADG decreased, F/G increased, and indicators of fat deposition and muscling increased with increases in body weight. It was determined that any of the five sire breeds evaluated would be acceptable for use as terminal sires in commercial crossbred lamb production, although combined F/G, ADG, and carcass traits were most desirable in Suffolk-sired lambs and least desirable in Polypay- and Border Leicester-sired lambs. Weight had the greatest effect on all performance traits studied.

Effects of Sire Breed on Growth, Feed Efficiency, and Carcass Traits of Crossbred Lambs Slaughtered at Three Weights

by

Debora Ann Collins

A THESIS
submitted to
Oregon State University

in partial fulfillment of
the requirements for the
degree of

Master of Science

Completed June 18, 1982
Commencement June 1983

APPROVED:

Redacted for Privacy

Professor of Animal Science in charge of major

Redacted for Privacy

Head of Department of Animal Science

Redacted for Privacy

Dean of Graduate School

Date thesis is presented June 18, 1982

Typed by Debora Ann Collins

ACKNOWLEDGEMENTS

I wish to extend my appreciation to the Animal Science Department for providing funds for this work, which was achieved during a time of university financial stress and state budget cuts.

My appreciation and gratitude are extended to Dr. David L. Thomas, whose guidance throughout my research and suggestions in writing this thesis helped to make this study a success. Special thanks to Dr. William D. Hohenboken for his assistance as an unofficial advisor during Dr. Thomas' absence. I also wish to thank Stephen E. Clarke for his computer skills and for his willingness to help in the statistical analysis. My appreciation is also extended to Toshie Gordon for the time and effort she provided in typing the tables.

I especially would like to thank my roommate, Julie T. Aurich, for providing technical guidance and access to the CH2M Hill computer on which this thesis was typed and edited. Thanks are also extended to Randall K. Thunell for his assistance in creating graphs and for his continual encouragement throughout my graduate study.

My deepest appreciation goes to my parents, Mr. and Mrs. David Collins, without whose love and support this experience would not have been possible.

Last of all, I wish to dedicate this research to Mr. Robert Klinger, whose complete lack of faith in my

ability served only to incite me to "endure to the end"!!!

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

EFFECTS OF SIRE BREED ON GROWTH, FEED EFFICIENCY, AND CARCASS TRAITS IN CROSSBRED LAMBS SLAUGHTERED AT THREE WEIGHTS

CHAPTER I

INTRODUCTION

A review of sheep crossbreeding studies by Nitter (1978) indicated that crossbreeding systems generally will result in increased lamb output compared to purebreeding systems. On the average, the weight of lamb weaned per ewe exposed has been increased by approximately 18% when purebred ewes produce crossbred lambs than when they produce purebred lambs. Furthermore, weight of lamb weaned per ewe exposed is increased by another 18% when F1 ewes, instead of purebred ewes, are used to produce crossbred lambs. These phenomena are commonly known as individual and maternal heterosis, respectively. The increases in lamb output due to individual and maternal heterosis are additive, so it can be expected that F1 crossbred ewes mated to an unrelated breed of sire will produce about 36% more kilograms of weaned lamb per ewe exposed than purebred ewes mated to produce purebred lambs. Therefore, to take advantage of both individual and maternal heterosis, most commercial sheep producers should be using crossbred ewes.

Since 1972, studies have been conducted at the Oregon State University Agricultural Experiment Station with the main objective of evaluating various F1 ewe groups for lifetime productivity under western Oregon conditions. From 1972 to 1978, eight F1 ewe groups produced by mating Finnish Landrace, Dorset, North Country Cheviot, and Romney sires to Columbia-type and Suffolk ewes were evaluated (Steele and Hohenboken, 1972a,b; Cedillo and Hohenboken, 1976; Hohenboken and Cochran, 1976; Hohenboken et al., 1976a,b; Hohenboken, 1976; Hohenboken, 1977; Levine and Hohenboken, 1978a,b; Torres-Hernandez et al., 1979a,b; Torres- Hernandez et al., 1980; Dally et al., 1980; Norman and Hohenboken,1980; Hohenboken and Clarke, 1981; Lamberson and Thomas, 1982).

In 1979, another study was initiated to evaluate five F1 ewe groups produced by mating Clun Forest, Polypay, Dorset, Border Leicester, and Suffolk sires to Columbia-type ewes. These latter five breeds are of interest for the following reasons:

> The Clun Forest is a British breed, well established in its native land, yet not presently popular in the United States. They are reported by their owners to be long-lived and very prolific. There is a moderate degree of interest in the breed by sheep producers in Oregon. One of the largest flocks of Clun

Forest sheep in the United States is owned by R.J. Hasbrouk of Oakland, Oregon.

The Polypay is a new breed of sheep developed by the U.S. Sheep Experiment Station at Dubois, Idaho. The original breed composition was 1/4 Finnish Landrace, 1/4 Targhee, 1/4 Dorset, and 1/4 Rambouillet. Current interest in the Polypay is high in Oregon.

The Border Leicester is not presently popular in the United States but is one of the major sire breeds used in the production of crossbred ewes in the United Kingdom, Australiia, and New Zealand. Two recent importations of Border Leicesters from New Zealand have been made by Oregon breeders.

The Dorset is included in both the 1972 to 1978 study and the current study to serve as a link between the two. Dorset sired lambs will then be represented in both studies, which will allow comparisons among all sire breeds from both studies.

The Suffolk breed is included because the vast majority of commercial ewes in western Oregon are crossbred Suffolk ewes. Therefore, Suffolk-sired lambs, will serve as a control group for the entire project.

Even though the relative productivity of an F1 ewe group when producing terminal crossbred lambs is the primary measure of the worth of that particular F1 ewe group to commercial sheep production, it is not the complete measure. When F1 ewe lambs are produced, a similar number of male lambs are produced also. If these "by-product" males have poor growth and carcass characteristics, they will reduce the value of the F1 ewes to the sheep production system. Therefore, a critical evaluation of the F1 males produced as half or full- sibs to the F1 ewes must be undertaken before a complete evaluation of the various F1 ewe groups can be made. Growth and carcass traits for the F1 male lambs produced by mating the Finnish Landrace, Dorset, North Country Cheviot, and Romney sires to Columbia-type and Suffolk dams has been reported by Hohenboken et al. (1976b).

The objectives of this study were to examine the growth, feed efficiency, and carcass traits of F1 male lambs produced by mating Clun Forest, Polypay, Dorset, Border Leicester, and Suffolk sires to Columbia-type ewes. Lambs were slaughtered at 43, 50, and 57 kg live weight. Effects of sire breed and weight on lamb performance are discussed.

CHAPTER II

LITERATURE REVIEW

Differences among breeds of sheep for various performance traits have been of interest to producers and researchers for many years. It is logical to assume, that because breeds have evolved due to selection for specific traits, one breed might have an advantage over another when evaluated for a particular characteristic. On the basis of this assumption, many breed comparisons have been performed to determine which breeds are superior for a particular trait or traits.

Studies comparing whitefaced vs blackfaced breeds have generally found significant differences in growth (Vesley and Peters, 1966; Antoniewiez and Pope, 1967; Glimp, 1971b; Hohenboken, 1981) and carcass characteristics (Southam and Field, 1969; Hohenboken, 1981), with the blackfaced breeds having an advantage. Studies examining eating quality, however, have found no significant differences between breeds (Fox et al., 1964; Solomon et al., 1980). Therefore, it is believed that differences between breeds exist for traits which determine quantity and efficiency of meat production (e.g., average daily gain, feed efficiency, carcass measurements), while breed differences for consumer preference measured by flavor, tenderness, or juiciness are relatively small. Evaluation of breeds in past studies have emphasized measuring these economically important traits and the factors influencing those traits.

Effects of the Clun Forest, Polypay, Dorset, Border Leicester, and Suffolk Breeds on Performance Traits

Comparison studies between two or three of the above breeds for growth, feed efficiency, and(or) carcass characteristics have been made by the following researchers:

1. Clun Forest (Wood et al., 1980; Wood and MacFie, 1980).

2. Dorset (Shelton and Carpenter, 1970; Dickerson et al., 1972; Fogarty, 1972; Barton and Purchas, 1974; Carter and Kirton, 1975; More O'Ferrall and Timon, 1977a,b; Makarechian et al., 1978; Atkins and Thompson, 1979; Cotterill and Roberts, 1979; Thompson et al., 1979a,b; Mitchell, 1980; Krupinski, 1981).

3. Border Leicester (Fogarty, 1972; Carter and Kirton, 1975; Atkins and Thompson, 1979;

Thompson et al., 1979a,b; Mitchell, 1980; Kempster et al., 1981).

4. Suffolk (Shelton and Carpenter, 1970; Dickerson et al., 1972; Barton and Purchas, 1974; Carter and Kirton, 1975; More O'Ferrall and Timon, 1977a,b; Makarechian et al., 1977; Makarechian et al., 1978; Cotterill and Roberts, 1979; Mitchell, 1980; Wood and MacFie, 1980; Krupinski, 1981; Kempster et al., 1981).

Unfortunately, there have been no previous studies comparing the Polypay with any of the other breeds for growth, feed efficiency, and(or) carcass traits.

Breed Effects on Growth:

It has been suggested that breed differences in performance traits may be due to differences in stage of maturity within the breeds. Wood et al. (1980) and Wood and MacFie (1980), in a study comparing the Clun Forest and Suffolk breeds, found the Clun Forest to be much fatter than the Suffolk at the same carcass weight. They believed that the differences were related to differences in potential mature size and stage of maturity of each breed at a constant carcass weight. Carter and Kirton (1975) evaluated 14 breeds for use as terminal sires in New Zealand. The Suffolk, Dorset Horn, and Border Leicester ranked, respectively, as the top three breeds in growth measured to an average slaughter age of 157 days. Likewise, Mitchell (1980) reported that Suffolk-sired lambs reached slaughter weight 13 days earlier than Dorset-sired lambs, who reached slaughter weight 11 days earlier than Border Leicester-sired lambs. Atkins and Thompson (1979) reported similar results. Although differences were not significant, Dorset sired lambs were younger upon reaching slaughter weight than lambs from Border Leicester sires. These findings agree with Fogarty (1972), who found that lambs sired by Dorset rams had a higher ($P<.05$) average daily gain (ADG) and were heavier than Border Leicester-sired lambs at similar slaughter ages of approximately five to six months.

Makarechian et al. (1978) compared the ADG of Suffolk- and Dorset-sired lambs to approximately 43 kg and found that Suffolk-sired lambs had higher ($P<.05$) postweaning ADG. This agrees with an Irish study by More O'Ferrall and Timon (1977a), who reported that Suffolk progeny had higher growth rates and were younger than Dorset progeny upon reaching slaughter weight. Similar results were reported by Krupinski (1981), who found ADG in Suffolk- sired lambs to be higher ($P<.05$) than in Dorset-sired lambs. Dickerson et al. (1972) compared seven ram breeds, including the Dorset and Suffolk, and reported that differences in relative growth among breeds were large and rather consistant from birth to 26 weeks of age. Relative to the overall mean after 10 weeks, Suffolks were observed as 115% body weight, whereas Dorsets were 85%. Shelton and Carpenter (1970), compared eight sire breeds and found that Suffolk-sired lambs gained at a faster rate than Dorset-sired lambs. They summarized their results by stating that significant breed of sire effects tended to be associated largely with rate of growth and earliness of maturity, with the most important effect being on growth rate of the offspring.

Breed Effects on Feed Efficiency:

Amount of feed required per unit of gain is a function of daily intake and daily gain (Sutherland, 1965). It is also dependent on the amount of feed required for maintenance and can be expressed as maintenance feed plus feed required per unit of live weight change. Doney and Russell (1968) reported that regression coefficients of gain on feed intake differed ($P<.05$) among Romney, Blackface, and Merino breeds of sheep. They computed values of 8.4, 9.2, and 14.0 g DOM (digestible organic matter)/kg/day for the three breeds, respectively. Estimates of requirements per unit change in live weight, after allowing for maintenance, were 5.1, 4.6, and 3.0 g DOM/g live weight change for the three breeds. These results confirmed Doney's (1967) implications that genetic differences due to inbreeding within a breed can be expected to affect maintenance requirements.

No available studies have reported feed efficiency comparisons between any of the five breeds: Clun Forest, Polypay, Dorset, Border Leicester, or Suffolk.

Breed Effects on Carcass Characteristics:

Breed has a marked effect on fat deposition (Wood et al., 1980). As growth rate is affected by stage of maturity, so is fat deposition. Wood et al. (1980) believed that breed differences in carcass traits were largely a function of stage of maturity relative to mature size of the breed. In their study involving purebred Clun Forest and Suffolk lambs, it was reported that Suffolk carcasses contained the least amount of subcutaneous and intermuscular fat. Cluns were observed to be the fattest of the four breeds studied, possessing significantly more internal fat. Cluns also had smaller loin-eye areas (LEA), measuring 15.9 cm^2, whereas Suffolks had LEA measurements of 17.4 cm^2.

Makarechian et al. (1978) and Krupinski (1981) observed that Dorset-sired lambs had higher ($P<.01$) dressing percentages than Suffolk-sired lambs. Makarechian et al. (1978) concluded that earlier maturing breeds, such as the Dorset, accelerated fat deposition at an earlier age than later maturing breeds and that the rate of these physiological processes in turn affected carcass composition when lambs were compared at a constant slaughter weight. Shelton and Carpenter (1970) also reported that Dorset-sired lambs fattened at a faster rate than Suffolk-sired lambs. Their Dorset-sired lambs had higher USDA conformation scores, dressing percentages, and USDA quality grades, and had more backfat than Suffolk-sired lambs. This would suggest that early maturing breeds should be competitive with later maturing breeds if both were compared at similar stages of physiological maturity. Their conclusion agreed with the findings of More O'Ferrall and Timon (1977b), who observed that Dorsets had a significantly higher carcass weight per day of age and a larger LEA than the Suffolks when slaughtered at lighter weights (36 and 45 kg). Cotterill and Roberts (1979) slaughtered Dorset-sired and Suffolk-sired lambs at a light weight (35 kg) and found no significant differences between the two breeds for dressing percentage, % kidney and pelvic fat, backfat, or loin eye area. Yet at heavier weights, Suffolk-sired lambs had an advantage over Dorset-sired lambs for all of these traits. Barton and Purchas (1974) in a New Zealand study involving nine sire breeds, with carcass weights ranging from 20 to 50 kg, found that Suffolk-sired lambs had slightly heavier ($P<.01$) carcasses than Dorset-sired lambs. Dickerson et al. (1972) evaluated the carcass traits of ram lambs from seven breeds when slaughtered at 22 or 26 weeks of age. They reported that the Dorset lambs excelled the Suffolk lambs in quality and yield grade but possessed less backfat over the 12th rib. The Suffolk lambs, however, had superior leg conformation scores and LEA measurements. The Suffolk lambs also had a much higher dressing percentage and more kidney and pelvic fat.

When compared with Border Leicester-sired lambs, Dorset- and Suffolk-sired lambs were reported to be significantly leaner and had cross sectional M. longissimus measurements superior to those of Border Leicester-sired lambs (Mitchell, 1980). Atkins and Thompson (1979) also found Border Leicester-sired lambs to have greater fat measurements over the 12th rib ($P<.05$) than Dorset-sired lambs. In a subsequent paper by Thompson et al.(1979b) examining carcass composition, Border Leicester-sired lambs had 12.7% more subcutaneous fat and 7.6% more intermuscular fat than Dorset-sired lambs at the same carcass weight ($P<.05$). Fogarty (1972), on the other hand, reported that Dorset-sired lambs had a higher dressing percentages than Border Leicester-sired lambs. This is indicative of greater fat deposition in Dorset-sired as opposed to Border Leicester-sired lambs.

Kempster et al. (1981) reported higher conformation scores in Suffolk-sired lambs than in lambs by Border Leicester sires ($P<.05$).

Based upon these studies of breed effects on ADG and carcass characteristics, it can be concluded that

Suffolk-sired lambs generally exhibit higher ADG and leaner carcasses than the Dorset-, Border Leicester-, or Clun Forest-sired lambs. However, because Clun Forest and Polypay lambs have not been studied in comparison with Dorset and Border Leicester lambs, it is not possible to project their performance against these breeds.

Relationship Between Slaughter Weight and Performance Traits

The following researchers have contributed information regarding the relationship between slaughter weight and growth, feed efficiency, and(or) carcass characteristics in lambs: (Antoniewiez and Pope, 1967; Botkin et al., 1967; Field et al., 1967; Southam and Field, 1969; Dickerson 1970; Fourie et al., 1970; Kemp et al., 1970; Lambuth et al., 1970; Rouse et al., 1970; Shelton and Carpenter, 1970; Hillers et al., 1971; Dickerson et al., 1972; Jacobs et al., 1972; Riley et al., 1972; Shelton and Carpenter, 1972; Steele and Hohenboken, 1972a,b; Vesley and Peters, 1972; Kemp et al., 1976; Thomas et al., 1976; Adams et al., 1977; Chant et al., 1977; Hohenboken, 1977; More O'Ferrall and Timon, 1977b; Webster, 1977; Herriman et al., 1978; Atkins and Thompson, 1979; Thompson et al., 1979b; Sents et al., 1980; Wood and MacFie, 1980; Kemp et al. 1981; Lloyd et al., 1981).

Weight Effects on Growth:

Antoneiweiz and Pope, (1967), Atkins and Thompson (1979), Jacobs et al. (1972), and Lloyd et al. (1981) observed little or no effect of changes in weight on growth rate. Many other studies, however, have reported that important differences occur in rate of gain with increases in body weight. Shelton and Carpenter (1972) observed negative changes in rate of gain as weight increased from 36 to 64 kg. Herriman et al. (1978) performed four trials using ram and ewe lambs where ADG was evaluated over two weight intervals, 31.8 to 45.5 kg and 45.5 to 56.8 kg. All trials showed a significant decline in ADG within the heavier weight interval. In a related paper by one of Herriman's associates, Adams et al. (1977), ADG for ram lambs at 31.8 to 45.5 kg and 45.5 to 56.8 kg was .37 and .32 kg, respectively. Over the same weight intervals, ewe lambs had ADG's of .28 and .21 kg, respectively. Sents et al. (1980) reported similar results in a study evaluating ram lambs slaughtered at four weights over three seasons. They reported an overall ADG of .29 kg at 31.8 to 45.5 kg live weight, .30 kg at 45.5 to 54.5 kg live weight, .28 kg at 54.5 to 63.6 kg live weight, and .28 kg at 63.6 to 72.7 kg live weight. Hillers et al. (1971) also reported significant differences in post weaning ADG of .30, .27, and .25 kg for lambs slaughtered at 45, 59, and 73 kg, respectively. It has been suggested that animals increase in body weight along a sigmoid curve until they reach a mature body size (Webster, 1977). Thus, an animal that is furthest from its mature size will have the greatest relative weight gain. Steele and Hohenboken (1972a), reported results which substantiated Webster's conclusion. They observed that rate of gain decreased at an increasing rate with advancing live weight.

Weight Effects on Feed Efficiency:

Rouse et al. (1970) reported that after 46 kg live weight, fat increased much more rapidly than lean tissue. Based on similar findings, Steele and Hohenboken (1972a) concluded it logical to expect that energy stored largely as fat deposition would require more feed (and thus be less efficient) than gains at lighter weights composed of larger proportions of lean. They suggested that the larger body mass which must be maintained each day at heavier weights, also contributed to decreased feed efficiency. Their study confirmed that feed consumption increased, yet rate of gain decreased, as live weight increased. This relationship was characterized by a steeper decline in efficiency as live weight increased. In a study comparing lambs slaughtered at 45.4 kg vs 59.0 kg, Antoniewiez and Pope (1967) reported differences in feed per kg of gain between the two weight endpoints ($P<.05$). Herriman et al. (1978) reported that ram and ewe lambs from 31.8 to 45.5 kg live weight required about 2.5 kg less feed per kg of gain than ram and ewe lambs fed from 45.5 to 56.8 kg. Sents et al. (1980), concluded that each kg of gain required more feed as live weight increased. By far the most efficient period of growth was from 31.8 to 45.5 kg.Such findings were interpreted by Webster (1977), who concluded that an animal which is farthest from its mature size will have the most efficient conversion of feed to lean body tissue.

Weight Effects on Carcass Characteristics:

As the weight of a carcass increases, the percentage edible portions of the carcass decrease (Kemp et al., 1970; Lambuth et al., 1970). This is due to the increased proportion of fat deposited at heavier weights. It is reported that as carcass weight increases, dressing percentage, backfat thickness, % kidney and pelvic fat, and quality grade increase, while yield grade becomes less desirable (Kemp et al. 1970; Lambuth et al., 1970; Shelton and Carpenter, 1970; Dickerson et al., 1972; Riley et al., 1972; Kemp et al., 1976; Thomas et al., 1976; Adams et al., 1977; Herriman et al., 1978; Sents et al., 1980; Kemp et al., 1981; Lloyd et al., 1981). Chant et al. (1977) observed that as weight increased, fat amount and percentage also increased. Fourie et al.

(1970) found that an increase in weight increased % fat and decreased % lean. More O'Ferrall and Timon (1977b) reported that a 2.5 kg increase in carcass weight resulted in a 3.3% increase in fat, but only a 2% increase in lean. Botkin et al. (1967) and Hohenboken (1977) agree that all carcass measurements increased with increasing carcass weight. These findings contradict Antoniewiez and Pope (1967), who earlier reported no increase in % muscle in the carcass, only increase in % fat, at heavier weights. Jacobs et al. (1972), Dickerson et al. (1972), Chant et al. (1977), and Lloyd et al. (1981) all reported increased leg conformation scores at heavier weights . LEA was also observed to increase as weight increased (Field et al., 1967; Southam and Field, 1969; Kemp et al., 1970; Lambuth et al., 1970; Rouse et al., 1970; Hillers et al., 1971; Dickerson et al., 1972; Jacobs et al., 1972; Vesley and Peters, 1972; Kemp et al., 1976; Adams et al., 1977; Herriman et al., 1978; Sents et al., 1980; Lloyd et al., 1981). Thomas et al. (1976) and Sents et al. (1980) reported an approximate 17% increase in LEA with a 25% increase in carcass weight. Leg and conformation scores were reported to increase 1/3 of a USDA grade with each additional 10 kg carcass weight (Steele and Hohenboken, 1972b). Dickerson et al. (1972) observed an increase of 1.9% in dressing percentage for a 4.9 kg increase in carcass weight between 22 and 26 weeks of age. Kemp et al. (1981) reported that up to 41 kg live weight, carcass weight per day of age increased significantly with increased carcass weight.

These findings all agree with Wood and MacFie (1980), who believed that muscle has a similar growth as fat as the carcass increases in weight. However, as lambs increase in weight and approach the top of their growth curve, they fatten at an increased rate (Lambuth et al., 1970) and in a disto-proximal pattern (Thompson et al., 1979b). This agrees with earlier work by Rouse et al. (1970), who reported that lambs fattened in a pattern anterior to posterior at weights above 50 kg live weight.

Summary

Significant differences between breeds have been reported for growth, feed efficiency, and carcass characteristics at a constant age or weight. Although breed differences have been observed, previous workers have reported a more marked effect on performance traits due to an increase in weight. Since the proportion of fat and muscle appear to be related to weight of the carcass, Wood et al. (1980) proposed that all breeds would have a similar carcass composition at the same degree of maturity. More O'Ferrall and Timon (1977b) agreed that lambs should be slaughtered at 60 to 66% of the mean adult weight of the parental breeds to optimize efficient lamb production. However, Dickerson (1970) suggests that the market weight chosen should be that weight where a heavier market weight begins to hurt carcass value and feed conversion more than it reduces production costs.

Running Head: Effects of sire breed on performance at three weights

CHAPTER III

Effects of Sire Breed on Growth, Feed Efficiency, and Carcass Traits of Crossbred Lambs Slaughtered at Three Weights [1,2]

Debora A. Collins , David L. Thomas[3]
and Stephen E. Clarke
Oregon State University, Corvallis 97331-6702

Key Words: Lamb, Breeds, Average Daily Gain, Feed Efficiency, Carcass, Weight

---

[1] Technical Paper No. 6465 , Oregon Agricultural Experiment Station. Contribution to North Central Regional Project III "Increased Efficiency of Lamb Production."

[2] Dept. Anim. Sci.

[3] Present address: Dept. Anim. Sci. Univ. of Illinos, Urbana 61801

Abstract

The effects of sire breed and weight on lamb performance were studied with 117 crossbred wether lambs produced by mating Clun Forest, Polypay, Dorset, Border Leicester, and Suffolk sires to Columbia-type ewes. After weaning at approximately 90 days of age (34 kg), the lambs were separated into two groups for experimentation, 1) 30 individually fed, and 2) 87 group fed lambs. Both groups were fed similar diets. Individually fed lambs were slaughtered at 57 kg live weight. Group fed lambs were randomly assigned live weights of 43, 50, and 57 kg. Average daily gain (ADG) and carcass data were collected from both groups; feed per gain (F/G) was also collected from the individually fed group. Lambs produced by the five sire breeds were similar for ADG and F/G. Differences were found among sire breeds for some carcass traits: loin-eye area ($P<.05$), leg conformation score ($P<.05$), flank streaking ($P<.10$), and USDA quality grade ($P<.10$). Weight increase greatly affected ADG ($P<.05$), F/G ($P<.01$), and carcass traits ($P<.01$). ADG decreased, F/G increased, and indicators of fat deposition and muscling increased with increases in body weight. It was determined that any of the five sire breeds evaluated would be acceptable for use as terminal sires in commercial crossbred lamb production, although combined

F/G, ADG, and carcass traits were most desirable in Suffolk-sired lambs and least desirable in Polypay- and Border Leicester-sired lambs. Weight had the greatest effect on all performance traits studied.

Introduction

F1 ewes mated to an unrelated breed of sire can wean approximately 18% more weight of lamb per ewe exposed than purebred ewes mated to the same unrelated breed of sire (Nitter, 1978). This suggests that most commercial sheep producers should be utilizing crossbred ewes in their production systems. Even though the relative productivity of an F1 ewe group when producing terminal-crossbred lambs is the primary measure of the worth of that particular F1 ewe group to commercial sheep production, it is not the final measure. When F1 ewe lambs are produced, there are a similar number of males produced. If these by-product males have poor growth or carcass characteristics, they will reduce the value of the F1 ewes to the sheep production system. Furthermore, since the maternal breeds that are usually used to produce F1 replacement ewes are small to medium in mature body size, optimum slaughter weights for these by-product males may be lower than for terminal-sired lambs. Therefore, an evaluation of the various F1 males produced as half- or full-sibs to the F1 ewes must be undertaken before a complete evaluation of the various F1 ewe groups can be made.

A study is currently underway at the Oregon Agricultural Experiment Station to evaluate the lifetime productivity of crossbred ewes produced by mating Clun Forest, Polypay, Dorset, Border Leicester, and Suffolk sires to Columbia-type ewes. The objective of this study was to compare the post-weaning average daily gain, feed efficiency, and carcass traits of the male siblings of the five F1 ewe groups when slaughtered at live weights of 43,50,or 57 kg.

Materials and Methods

After weaning at approximately 90 d of age, 117 crossbred wether lambs produced by mating Clun Forest, Polypay, Dorset, Border Leicester, and Suffolk sires to mature Columbia-type ewes were fed to slaughter weight in individual or group pens. A 12% crude protein , pelleted diet consisting of ryegrass-clover hay, corn (IFN 4-02-931), soybean meal (IFN 5-04-604), and sugar cane molasses (IFN 4-04-696) and a salt-phenothiazine mixture (69% trace mineralized salt, 23% calcium carbonate, and 8% phenothiazine) was fed ad libitum. Lambs were placed in the pens and fed the rations for 1 wk before the trial was initiated.

Individually Fed Lambs. The 30 lambs, 6 from each of the 5 sire breed groups, that had the smallest deviations from the average 90 d weight of their respective sire breed group were fed in individual pens to a minimum live weight of 57 kg. Individual pens were 1.22 m x 1.22 m and were on 1.9 cm expanded metal flooring. Feed was weighed and placed in feeders twice daily.Unconsumed feed was removed weekly and weighed. The amount of unconsumed feed was subtracted from the total amount fed each week to determine feed consumption per lamb per week. Lambs were weighed weekly and repenned at random. Due to anticipated limited slaughtering capacity at the Oregon State University Meat Science Laboratory, it was originally planned to slaughter only the group fed lambs. As the study progressed, however, it was decided that more lambs could be slaughtered. Therefore, all of the individually fed lambs except those that had already reached 57 kg at the time of this decision were also slaughtered. Carcass data were not collected on 1 Polypay-, 2 Dorset-, 1 Border Leicester-, and 4 Suffolk-sired lambs.

Group Pens. The remaining 87 lambs were randomly assigned to 1 of 3 slaughter weights (43, 50, or 57 kg) within breed of sire and fed in groups of 29 lambs per pen. As lambs reached their pre-designated slaughter weight and were removed from the study, remaining lambs were regrouped into new pens. Therefore, as the trial progressed, the number of pens in use varied from 3 to 1. Lambs were fed ad libitum. No attempt was made to record feed consumption. Lambs were weighed each week and were slaughtered as they reached their pre-designated slaughter weight. All group-fed lambs were slaughtered at the Oregon State University Meat Science Laboratory except 4 lambs which had not reached their pre-designated slaughter weight (1 Clun Forest-sired lamb to 57 kg, 2 Polypay-sired lambs to 57 kg, and 1 Dorset-sired lamb to 57 kg) at the termination of the study on November 6, 1981.

Carcass Traits. Lambs were weighed each Friday; those lambs reaching their pre-designated slaughter weight were sent to slaughter the following Monday after being penned over night without feed or water. Carcasses were allowed to chill for approximately 24 hr before measurements were taken. Information collected on each carcass included chilled carcass weight, leg conformation score, estimated % kidney and pelvic fat, fat thickness over the M. longissimus between the 12th and 13th rib, degree of feathering, flank streaking, flank fullness, loin-eye area determined by using a compensating polar planimeter on tracings of the cross-section of the M. longissimus between the 12th and 13th rib, yield and quality grades using the official United States Department of Agriculture Standards (USDA, 1981).

Statistical Analysis. Data were analyzed by least-squares analysis of variance (Harvey, 1977). Average daily gain and carcass traits were analyzed using a model in which the independent variables were breed of sire, sire within breed, type of birth-rearing (multiple-multiple, multiple-single, single-single, or multiple reared artificially), slaughter weight (group fed lambs to 43, 50, or 57 kg vs individually fed lambs to 57 kg) and the interactions between breed of sire and slaughter weight,and between breed of sire and rearing type. The breed of sire mean square was tested with the sire within breed of sire mean square. All other mean squares were tested with the residual mean square. Feed efficiency (F/G) of the individually fed lambs was analyzed using a model in which the independent variables were breed of sire, lambs within breed of sire, weight interval (initial weight (I) - 43 kg, 43 - 50 kg, 50 - 57 kg) and the breed of sire by weight interval interaction. The breed of sire mean square was tested with the lambs within breed of sire mean square. All other mean squares were tested with the remainder mean square. Significance levels among means were determined using the Bonferroni-t test (Gill, 1978).

Results and Discussion

Feed Efficiency. Least-squares analysis of variance for feed per unit of gain (F/G) of the individually fed lambs averaged over the three weight intervals examined (initial weight(I) - 43 kg, 43 - 50 kg, 50 - 57 kg), showed no significant differences among sire breeds (table 1). However, the breed means presented in table 2, which are similar to the least-squares means for F/G over the entire I - 57 kg interval, are greatest for Polypay- and Clun Forest-sired lambs, intermediate for Dorset- and Border Leicester-sired lambs, and least for Suffolk-sired lambs.

Differences ($P<.01$) were found among the weight intervals for F/G (tables 1 and 2). Greater amounts of feed were required per unit of gain as lamb weight increased. During the interval from initial weight to 43 kg, lambs required an average of 6.8 kg of feed to produce a kg of gain. During the 43 to 50 kg body weight interval, F/G increased by 1.5 to a F/G value of 8.3, and during the 50 to 57 kg body weight interval, the kg of feed required to produce a kg of gain was increased by another 1.7 kg for a F/G value of 10.0. These results agree with Steele and Hohenboken (1972a), who suggested that fat deposition at heavier weights required more feed than gains resulting from muscle growth and development

TABLE 1. LEAST-SQUARES ANALYSIS OF VARIANCE FOR FEED PER GAIN OF 30 INDIVIDUALLY FED LAMBS

Source	Degrees of freedom	Mean square
Breed	4	2.65
Lambs within breed (L/B)[a]	25	3.40
Wt interval[b]	2	77.78**
Breed x wt interval	8	7.23†
Remainder (R)	50	4.01

[a] L/B mean square used to test breed mean square. All other mean squares tested with R mean square.

[b] Weight intervals = initial wt – 43 kg, 43-50 kg, 50-57 kg.

† $P<.10$.

** $P<.01$.

TABLE 2. FEED PER GAIN OF INDIVIDUALLY FED LAMBS AT EACH WEIGHT INTERVAL

Sire breed	No.	Initial wt	Wt interval (kg)			Breed mean
			I[a]-43	43-50	50-57	
Clun Forest	6	33.8	6.8	8.0	10.8	8.5
Polypay	6	32.4	6.9	7.5	12.1	8.9
Dorset	6	33.8	7.1	8.4	9.0	8.2
Border Leicester	6	33.3	6.3	9.1	9.6	8.3
Suffolk	6	33.9	6.7	8.6	8.3	7.8
Wt mean		33.5	6.8[b]	8.3[c]	10.0[d]	

[a]Initial weight.

[b,c,d]Row means with different superscripts differ ($P<.01$) by Bonferroni-t test.

occurring at lighter weights, and that the larger body mass which must be maintained each day at the heavier weights also may have contributed to higher F/G values.

The tendency towards statistical significance of the breed x wt interaction (table 1) indicates that the increase in F/G as weight increases may differ among breeds of sire. Differences among breeds of sire were quite small (figure 1) during the initial weight to 43 kg interval. However, as weight increased from 43 to 50 kg, Border Leicester-, Suffolk-, and Dorset-sired lambs were observed to have greater F/G values than Clun Forest- or Polypay-sired lambs. From 50 to 57 kg, the Border Leicester-, Dorset-, and Suffolk-sired lambs appeared to have stabilized in F/G values whereas the Clun Forest- and Polypayed-sired lambs displayed a steep increase in F/G. This may be due to differences in mature body size among the 5 sire breeds. Clun Forest- and Polypay-sired lambs, known to mature at 70 to 80 kg, showed a greater increase in F/G values compared to the Border Leicester- , Dorset-, and Suffolk-sired lambs known to mature at much larger weights of 90 to 115 kg.

These data indicate that when slaughtered at normal U.S. slaughter weights of 43 to 50 kg live weight, lambs by all 5 sire breeds would have similar F/G values from weaning to market. However, when fed to heavier weights, Polypay- and Clun Forest-sired lambs would be less efficient converters of feed to body weight gain than

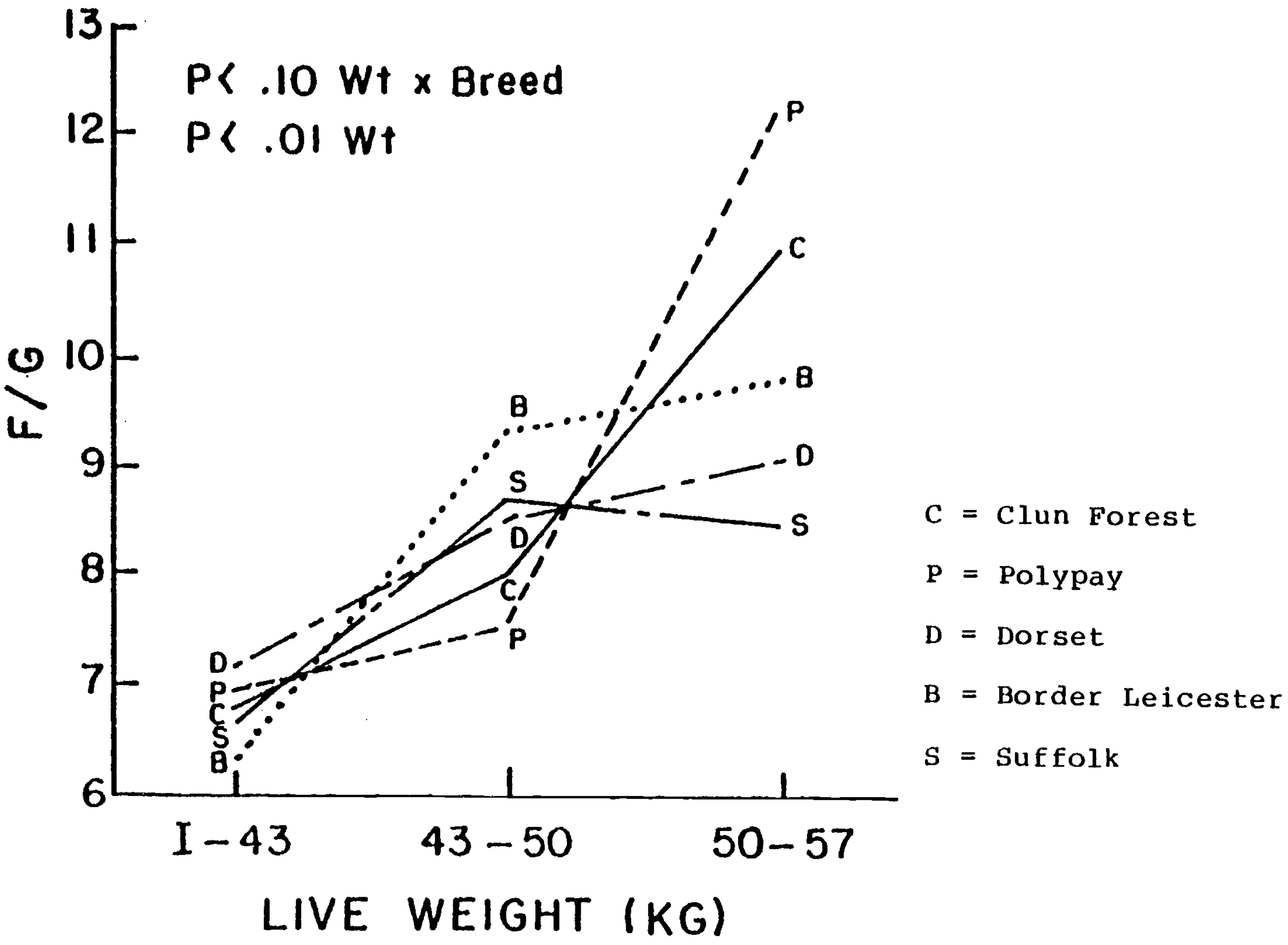


Figure 1. Feed per gain of individually fed lambs during three weight intervals.

lambs sired by the other three breeds.

Average Daily Gain (ADG). Lamb ADG averaged over the four slaughter weight classes (group fed to either 43, 50, or 57 kg, or individually fed to 57 kg) was not significantly affected by breed of sire (tables 3 and 4). However, the breed means for ADG over the four weight classes appeared greatest for the Suffolk- and Border Leicester-sired lambs, intermediate for Dorset- and Polypay-sired lambs and least for Clun Forest-sired lambs. These results are similar to those reported by previous workers (Shelton and Carpenter, 1970; Dickerson et al., 1972; Fogarty, 1972; Carter and Kirton, 1975; More O'Ferrall and Timon, 1977a; Makarechian et al., 1978; Atkins and Thompson, 1979; Mitchell, 1980), except that a number of those studies reported Dorset-sired lambs superior to Border Leicester-sired lambs for ADG.

Slaughter weight had a significant effect on ADG with lambs slaughtered at 43 kg live weight having ADG at least .04 kg superior to the ADG of lambs slaughtered at heavier weights. This confirms studies by Hillers et al. (1971), Adams et al. (1977), Herriman et al. (1978), and Sents et al. (1980), who reported that lamb ADG decreased with increased body weight. In this study (figure 2), a decrease of ADG was observed within each of the sire breeds as weight increased. At the heaviest weight interval, Border Leicester-, Dorset-, and Suffolk-sired lambs continued to gain at a steady rate whereas the Clun

TABLE 3. LEAST-SQUARES ANALYSIS OF VARIANCE FOR AVERAGE DAILY GAIN (KG) OF GROUP AND INDIVIDUALLY FED LAMBS

Source	Degrees of freedom	Mean square
Breed	4	.002
Sire within breed (S/B)[a]	10	.003
Birth-rearing type[b]	3	.020*
Wt class[c]	3	.015*
Breed x wt class	12	.002
Remainder (R)	80	.005

[a]S/B mean square used to test breed mean square. All other mean squares tested with R mean square.

[b]Birth-rearing type: 1=multiple reared multiple; 2=multiple reared single; 3=single reared single; 4=multiple reared artificially.

[c]Wt class=43, 50, 57 (group) or 57 (individual).

*P<.05

TABLE 4. AVERAGE DAILY GAIN (KG) OF LAMBS FROM INITIAL WEIGHT TO ASSIGNED SLAUGHTER WEIGHT

Sire breed	Initial wt	Slaughter wt (kg)[a]				Breed mean
		43[b]	50[b]	57[b]	57[c]	
Clun Forest	35.4	.29 (3)	.26 (5)	.23 (5)	.21 (6)	.25 (19)
Polypay	34.2	.29 (8)	.29 (8)	.22 (6)	.24 (6)	.26 (28)
Dorset	35.3	.28 (6)	.25 (6)	.24 (5)	.26 (6)	.26 (23)
Border Leicester	34.6	.33 (4)	.24 (4)	.25 (5)	.25 (6)	.27 (19)
Suffolk	37.3	.30 (6)	.26 (7)	.26 (5)	.27 (6)	.27 (24)
Wt mean	35.6	.30 (27)[d]	.26 (30)[e]	.24 (26)[e]	.25 (30)[e]	.26 (113)

[a]Values in parenthesis are number of observations.

[b]Group fed.

[c]Individually fed.

[d,e]Row means with different superscripts differ ($P<.05$) by Bonferroni-t test.

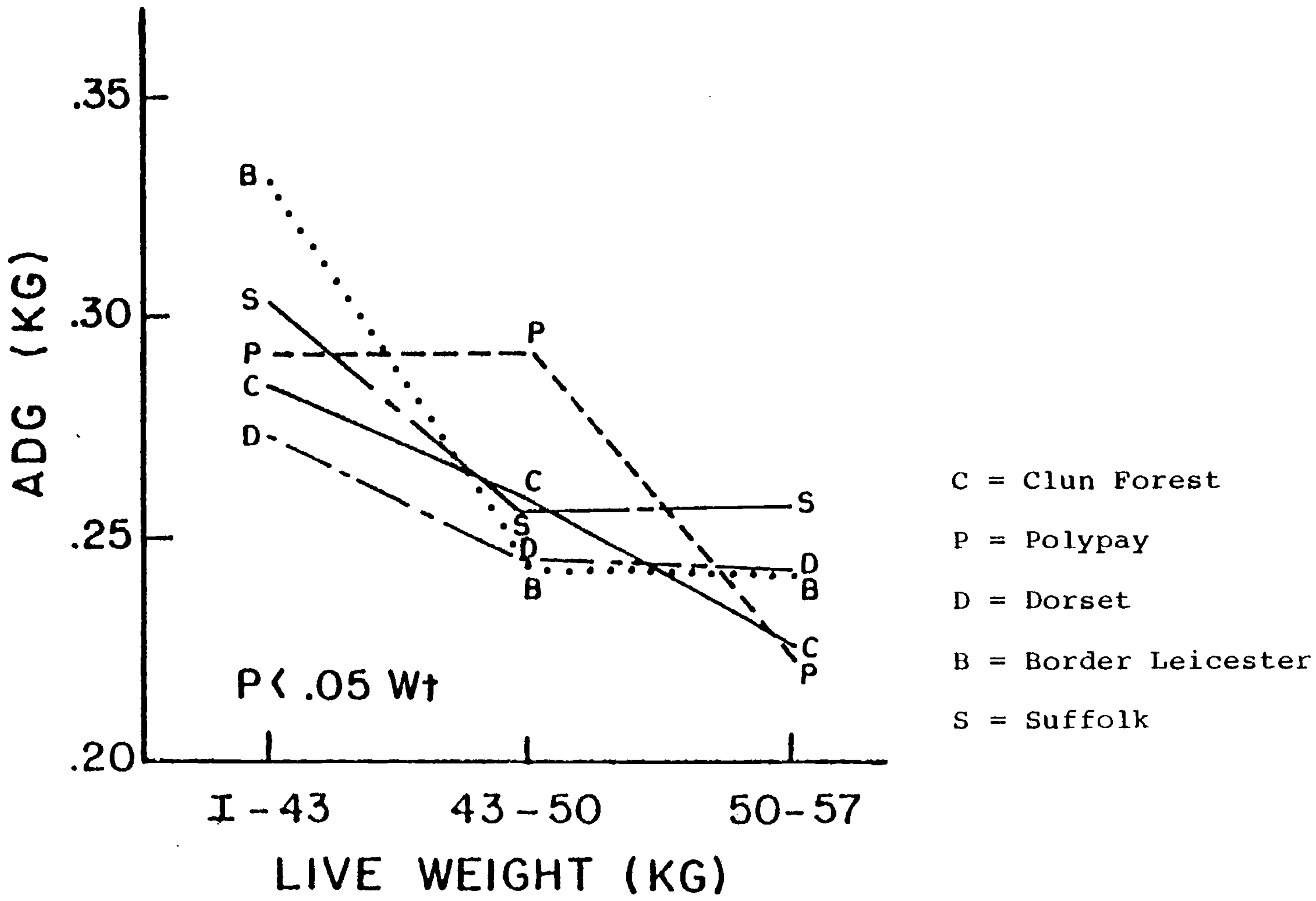


Figure 2. Average daily gain of group fed lambs during three weight intervals.

Forest- and Polypay-sired lambs experienced a steep decline. These weight effects substantiate findings by Webster (1977), who concluded that the animal farthest from its mature size will have the greatest relative weight gain. Also, the relative decline in ADG within each of the sire breeds in this study agree with Steele and Hohenboken (1972a), who also observed that rate of gain decreased with advancing live weight and at an increasing rate.

The difference in ADG between lambs fed individually vs lambs fed in groups to 57 kg was small and non-significant (table 4).

Type of birth and rearing had a large effect on ADG with single born and reared lambs showing higher ($P<.05$) gains than lambs born multiple and reared artificially. This agrees with Hohenboken et al. (1976b), but is contrary to findings of Makarechian et al. (1978) and Glimp (1971a), who reported little or no differences between singles and twins in post-weaning growth.

Carcass Traits. Least-squares analysis of variance of carcass traits (table 5) showed lambs from the various sire breeds to differ in loin-eye area (LEA), leg conformation score, flank streaking, and USDA quality grade. Sire within breed was a significant source of variation for backfat thickness, quality grade, and two determining factors of quality grade, i.e. feathering and flank fullness and firmness. Significant differences

TABLE 5. LEAST-SQUARES ANALYSIS OF VARIANCE FOR CARCASS TRAITS OF GROUP AND INDIVIDUALLY FED LAMBS

Source	Degrees of freedom	Mean square									
		Dress %	L.E.A.[c] (cm^2)	Leg[d] score	K.P.F.[e] %	B.F.[f] (mm)	Feathr[g] score	Flank[h] str.	Flank[i] full.	U.S.D.A.[j] yield	U.S.D.A.[k] quality
Breed	4	6.99	8.77*	2.26*	.18	11.98	2.00	3.47†	1.19	1.08†	.28
Sire within breed (S/B)[a]	10	7.54	1.92	.60	.15	5.60†	1.53*	1.35	.84†	.42	.21†
Birth-rearing type[b]	3	18.47	4.74	.03	.20	1.37	4.30**	1.30	.27	.29	.29†
Wt class	3	97.92**	30.80**	15.09**	3.55**	81.89**	22.91**	28.94**	2.48**	7.36**	2.89**
Breed x wt class	12	10.42	2.05	.88	.15	2.95	.59	.76	.24	.27	.24*
Remainder (R)	72	9.61	3.00	.66	.21	3.33	.78	1.04	.50	.29	.11

[a] S/B mean square used to test breed mean square. All other mean squares tested with R mean square.

[b] Birth-rearing type: 1=multiple reared multiple; 2=multiple reared single; 3=single reared single; 4=multiple reared artificially.

[c] Loin-eye area (cm^2) averaged from both sides of 12th-13th rib interface.

[d] Leg score: 10 to 12 = Choice; 13 to 15 = Prime.

[e] % kidney and pelvic fat.

[f] Back fat thickness (mm) averaged from both sides of 12th-13th rib interface.

[g] Feathering score: 1 to 3 = Traces; 4 to 6 = Modest.

[h] Flank streaking: 1 to 3 = Traces; 4 to 6 = Small.

[i] Flank fullness: 1 = Thin, 2 to 4 = Full.

[j] U.S.D.A. Yield grade: 1 to 5 (U.S.D.A., 1981).

[k] U.S.D.A. Quality grade: 10 to 12 = Choice; 13 to 15 Prime (U.S.D.A., 1981).

† $P<.10$.

* $P<.05$.

** $P<.01$.

among progeny groups for these traits indicate that they may have a relatively high heritability and may respond to selection. Birth-rearing type had little effect on most carcass traits, which agrees with the results of Makarechian et al. (1978) and Lloyd et al. (1981). Weight affected all traits examined (P<.01).

For traits that differed among breeds (table 6) the Suffolk-sired lambs ranked above the Polypay-sired lambs (P<.05) in LEA; Clun Forest-, Suffolk-, and Dorset-sired lambs were superior (P<.05) in leg conformation score. Suffolk-sired lambs had the most desirable yield grade indicating the highest lean:fat ratio, whereas the Border Leicester-sired lambs possessed the poorest yielding carcasses. However, these findings were not significantly different. Flank streaking and USDA quality grades differed slightly among sire breeds (P<.10), with Dorset-sired lambs exhibiting more abundant streaking than the other breeds. Border Leicester-sired lambs had the highest USDA quality grade, followed by the Dorset-, Clun Forest-, Suffolk-, and Polypay-sired lambs, respectively. Similar results were reported by Atkins and Thompson (1979b) and Mitchell (1980), who observed Suffolk- and Dorset-sired lambs to be leaner with cross sectional M. longissimus measurements superior to those of Border Leicester-sired lambs.

Increases in slaughter weight affected all traits (P<.01),with individually and group fed lambs slaughtered

TABLE 6. CARCASS TRAITS OF GROUP AND INDIVIDUALLY FED LAMBS

		Carcass trait									
	No.	Dress %	L.E.A.[c] (cm^2)	Leg[d] score	K.P.[e] %	B.F.[f] (mm)	Feathr[g] score	Flank[h] str.	Flank[i] full	U.S.D.A.[j] yield	U.S.D.A.[k] quality
Sire breed											
Clun Forest	19	58.1	14.0^{op}	12.7^{o}	2.70	6.8	3.4	3.3^{m}	3.0	3.44	12.2^{lm}
Polypay	27	51.4	13.0^{p}	11.9^{p}	2.76	6.0	3.4	3.6^{m}	2.6	3.29	11.5^{n}
Dorset	21	52.5	13.9^{op}	12.5^{o}	2.89	6.5	4.0	4.3^{l}	3.1	3.41	12.3^{lm}
Border leicester	18	51.5	13.9^{op}	12.2^{op}	2.86	6.5	3.5	3.6^{m}	2.8	3.53	12.4^{l}
Suffolk	20	51.0	15.0^{o}	12.5^{o}	2.66	4.6	3.3	3.1^{m}	2.5	2.87	12.1^{m}
Slaughter weight (kg)											
43[a]	27	48.7^{s}	12.4^{s}	11.2^{s}	2.31^{s}	3.7^{s}	2.3^{t}	2.2^{t}	2.4^{s}	2.60^{s}	10.9^{t}
50[a]	30	51.7^{r}	13.9^{r}	12.4^{r}	2.54^{r}	5.3^{r}	3.0^{s}	2.9^{s}	2.9^{r}	3.03^{r}	11.5^{s}
57[a]	26	52.7^{qr}	15.1^{q}	13.0^{q}	3.06^{q}	7.3^{q}	4.0^{r}	4.3^{r}	3.2^{q}	3.71^{q}	12.6^{r}
57[b]	22	53.8^{q}	14.4^{qr}	12.9^{q}	3.19^{q}	8.1^{q}	4.8^{q}	4.8^{q}	2.6^{s}	3.89^{q}	13.4^{q}

[a]Group fed.

[b]Individually fed.

[c]Loin-eye area (cm^2) averaged from both sides of 12th-13th rib interface.

[d]Leg score: 10 to 12 = Choice; 13 to 15 = Prime.

[e]% kidney and pelvic fat.

[f]Back fat thickness (mm) averaged from both sides of 12th-13th rib interface.

[g]Feathering score: 1 to 3 = Slight; 4 to 6 = Modest.

[h]Flank streaking: 1 to 3 = Traces; 4 to 6 = Small.

[i]Flank fullness: 1 = Thin; 2 to 4 = Full.

[j]U.S.D.A. Yield grade: 1 to 5 (U.S.D.A., 1981).

[k]U.S.D.A. Quality grade: 10 to 12 = Choice; 13 to 15 = Prime (U.S.D.A., 1981).

[l,m,n]Column means with different superscripts differ ($P<.10$) by Bonferroni-t test.

[o,p]Column means with different superscripts differ ($P<.05$) by Bonferroni-t test.

[q,r,s,t]Column means with different superscripts differ ($P<.01$) Bonferroni-t test.

at 57 kg having similar values. Effects of weight increase on carcass traits have also been reported by Steele and Hohenboken (1972b), Thomas et al. (1976), and Sents et al. (1980). Weight effects on carcass merit can more readily be seen when graphically comparing USDA yield grade (figure 3) with USDA quality grade (figure 4). As weight increased, yield and quality grades also increased, indicating fatter carcasses. More O'Ferrall and Timon (1977b) reported that a 2.5 kg increase in carcass weight resulted in a 3.3% increase in fat, while only a 2% increase in lean. Note that breed rankings are relatively similar for USDA yield grade and USDA quality grade at each slaughter weight. Border Leicester- and Clun Forest-sired lambs had not only the highest quality (fattest) carcasses, but also the highest yield grade (less lean:fat). The Suffolk-sired lambs, however, are observed as having not only a relative average USDA quality grade, but more important the most desirable USDA yield grade. This low amount of fat, coupled with the desirable muscle characteristics as observed in LEA and leg measurements are some of the reasons why the Suffolk is the most popular sire breed in the United States.

In summary, F/G, ADG, and carcass traits combined were most desirable in the Suffolk-sired lambs relative to the Clun Forest-, Dorset-, Border Leicester-, and Polypay-sired lambs, with the Clun Forest- and

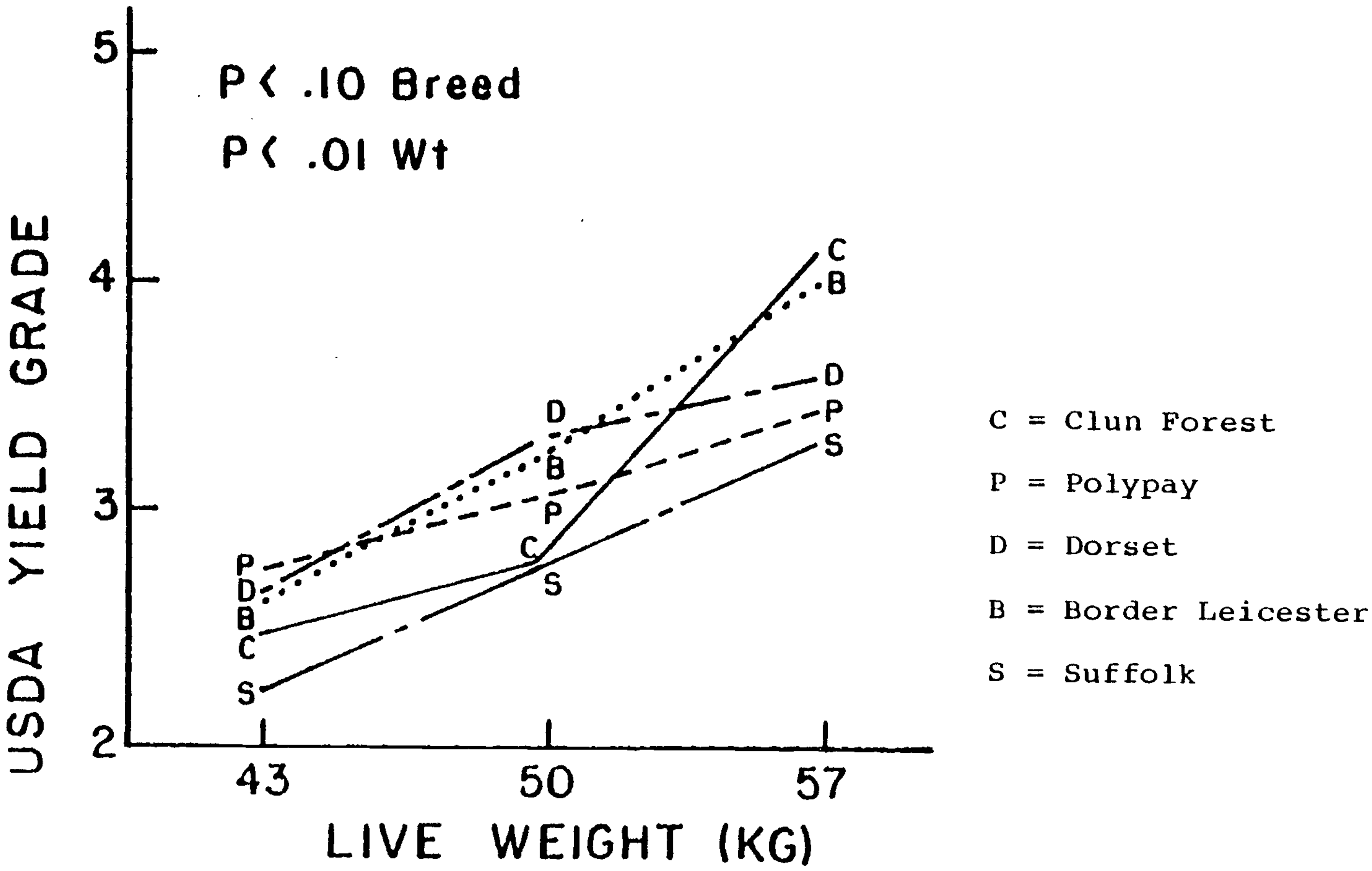


Figure 3. USDA yield grade for group and individually fed lambs at three slaughter weights.

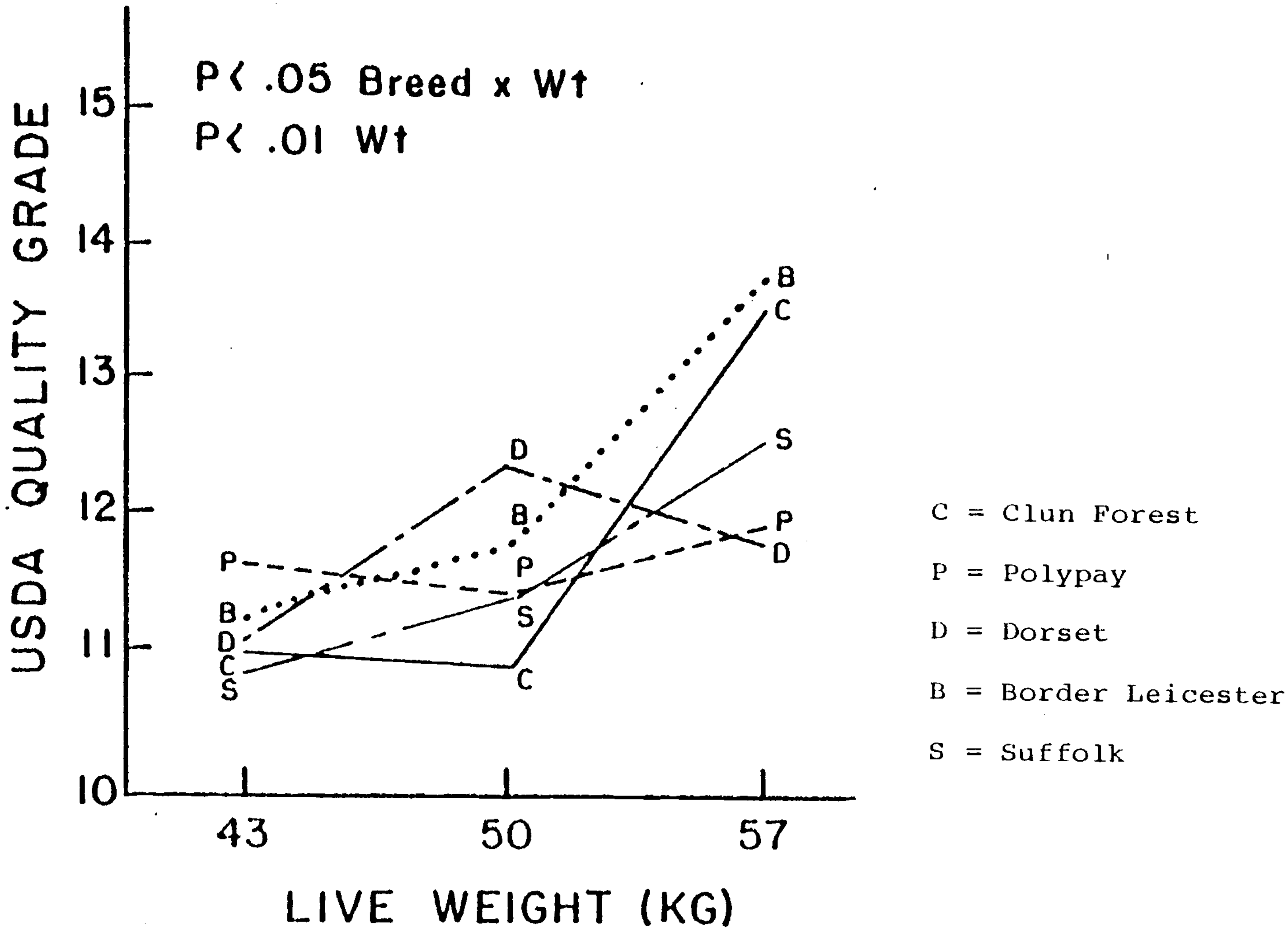


Figure 4. USDA quality grade for group and individually fed lambs at three slaughter weights.

Dorset-sired lambs observed as being fatter yet muscular lambs, while the Polypay- and Border Leicester-sired lambs were found to be less muscular and more fat. However, the insignificance found for most traits among these breeds indicate that the differences observed are quite small, therefore any of the sire breeds evaluated in this study would be acceptable as terminal sires in commercial crossbred lamb production.

LITERATURE CITED

Adams, R.L., L.E. Walters, J.V. Whiteman and J.E. Fields. 1977. Feed efficiency and carcass characteristics of ram and ewe lambs slaughtered at two live weights. Oklahoma State Univ. and USDA Res. Rep. MP-101. p 114.

Antoniewiez, R.J. and A.L. Pope. 1967. Effects of age and weight on feed efficiency and carcass composition of lambs. J. Anim. Sci. 26:1487 (Abstr.).

Atkins, K.D. and J.M. Thompson. 1979. Carcass characteristics of heavyweight crossbred lambs. I. Growth and carcass measurements. Australian J. Agr. Res. 30:1197.

Barton, R.A. and R.W. Purchas. 1974. Influence of breed of sire, sex, and carcass grade on measurements and proportions of primal cuts of lamb carcasses. New Zealand J. Exp. Agr. 2:213.

Botkin, M.P., C.O. Schoonover and R.A. Field. 1967. Relationships between live and carcass traits of lambs. Res. J. 6. Wyoming Agr. Exp. Sta., Laramie.

Carter, A.H. and A.H. Kirton. 1975. Lamb production performance of 14 sire breeds mated to New Zealand Romney ewes. Livestock Prod. Sci. 2:157.

Cedillo, R.M. and W. Hohenboken. 1976. Breed effects on income generated per ewe bred. Proc. West. Sec. Amer. Soc. Anim. Sci. 27:23.

Chant, J.L., R.A. Field and M.L. Riley. 1977. Effects of sex, energy and weight on lamb carcass composition. J. Anim. Sci. 45 (Suppl. 1): 60.

Cotterill, P.P. and E.M. Roberts. 1979. Crossbred lamb growth and carcase characteristics of some Australian sheep breeds. Australian J. Exp. Agr. Anim. Husb. 19:407.

Dally, M.R., W.D. Hohenboken, D.L. Thomas and A.M Craig. 1980. Relationships between hemoglobin type and reproduction, lamb, wool and milk production and health-related traits in crossbred ewes. J. Anim. Sci.50:418.

Dickerson, G.E. 1970. Effiency of animal production-modling the biological components. J. Anim. Sci. 30:849.

Dickerson, G.E., H.A. Glimp, H.J. Tuma and K.E. Gregory. 1972. Genetic resources for efficient meat production in sheep. Growth and carcass charactersistics of ram lambs of seven breeds. J. Anim. Sci. 34:940.

Doney, J.M. 1967 The effect of inbreeding on food consumption and utilization by sheep. Anim. Prod. 9:359.

Doney, J.M. and A.J.F. Russell. 1968. Differences amongst breeds of sheep in food requirements for maintenance and live-weight change. J. Agr. Sci. (Cab). p 343.

Field, R.A., M.L. Riley and M.P. Botkin. 1967. Effect of sex and ram weight on composition of lambs. J. Anim. Sci. 26:894 (Abstr.).

Fogarty, N.M. 1972. Crossbreeding for lamb production. 1. Survival and growth of first cross lambs. Australian J. Exp. Agr. Anim. Husb. 12:234.

Fourie, P.D., A. H. Kirton and K E. Jury. 1970. Growth and development II. Effect of breed and sex on the growth and carcass composition of the Southdown and Romney and their cross. New Zealand J. Agr. Res. 13:753.

Fox, C.W., R. Eller, L. Sather and J.A.B. McArthur. 1964. Effect of sire and breed on eating qualities from weaning lambs. Proc. West. Sec. Amer. Soc. Anim. Sci. 15:XXIII.

Gill, J.L. 1978. Design and analysis of experiments in the animal and medical sciences. Vol. I. Iowa State Univ. Press, Ames. p 176.

Glimp, H.A. 1971a. Effects of sex alteration, breed, type of rearing and creep feeding on lamb growth. J. Anim. Sci. 32:859.

Glimp, H.A. 1971b. Effect of breed, ration energy level and their interactions on rate and efficiency of lamb growth. J. Anim. Sci. 33:157.

Harvey, W.R. 1977. User's Guide For LSML76. Ohio State Univ., Columbus. Mimeograph.

Herriman, R.D., R.L. Adams, L.E. Walters, J.V. Whiteman and J.E. Fields. 1978. Comparison of feed efficiency for two weight intervals and carcass composition at two market weights of ram and ewe lambs. Oklahoma

State Univ. Res. Rep. MP-103. p 140.

Hillers, J.K., M.W. Galgan and E.L. Martin. 1971. Effects of live weight on lamb traits. J.Anim. Sci. 33:201 (Abstr.).

Hohenboken, W.D. 1976. Genetic, environmental and interaction effects in sheep. III. Wool production and gross income per ewe. J. Anim. Sci. 42:317.

Hohenboken, W.D. 1977. Genetic and environmental effects on postweaning growth and carcass merit of crossbred lambs. J. Anim. Sci. 45:1261.

Hohenboken, W.D. 1981. Breed evaluation research in western Oregon: Experimental plan and results of satellite studies. Oregon State Univ. Special Rep. 613. p 8.

Hohenboken, W.D. and S.E. Clarke. 1981. Genetic, environmental and interaction effects on lamb survival, cumulative lamb production and longevity of crossbred ewes. J. Anim. Sci. 63:966.

Hohenboken, W.D. and P.E. Cochran. 1976. Heterosis for ewe lamb productivity. J. Anim. Sci. 42:819.

Hohenboken, W.D., K. Corum and R. Bogart. 1976a. Genetic, environmental and interaction effects in sheep. I. Reproduction and lamb production per ewe. J. Anim. Sci. 42:299.

Hohenboken, W.D., W.H. Kennick and R. Bogart. 1976b. Genetic, environmental and interaction effects in sheep. II. Lamb growth and carcass merit. J. Anim. Sci. 42:307.

Jacobs, J.A., R.A. Field, M.P. Botkin, M.L. Riley and G.P. Roehrkasse. 1972. Effects of weight and castration on lamb carcass composition and quality. J. Anim. Sci. 35:926.

Kemp, J.D., J.D. Crouse, W.D. DeWeese and W.G. Moody. 1970. Effect of slaughter weight and castration on carcass characteristics of lambs. J. Anim. Sci. 30:348.

Kemp, J.D., D.G. Ely, J.D. Fox and W.G. Moody. 1981. Carcass and meat characteristics of crossbred lambs with and without Finnish Landrace breeding. J. Anim. Sci. 52:1026.

Kemp, J.D., A.E. Johnson, D.F. Stewart, D.G. Ely and J.D.

Fox. 1976. Effect of dietary protein, slaughter weight and sex on carcass composition, organoleptic properties and cooking losses of lambs. J. Anim. Sci. 42:575.

Kempster, A.J., D. Croston and D.W. Jones. 1981. Value of comformation as an indicator of sheep carcass composition within and between breeds. Anim. Prod. 33:39.

Krupinski, J. 1981. Lamb meat production from Polish Merino ewes sired by English meat breeds. Anim. Breed. Abstr. 49:2643 (Abstr.).

Lamberson, W.R. and D.L. Thomas. 1982. Effects of season and breed of sire on incidence of estrus and ovulation rate in sheep. J. Anim. Sci. 54:533.

Lambuth, T.R., J.D. Kemp and H.A. Glimp. 1970. Effect of rate of gain and slaughter weight on lamb carcass composition. J. Anim. Sci. 30:27.

Levine, J.M. and W.D. Hohenboken. 1978a. Crossbred lamb production from Columbia and Suffolk ewes. I. Ewe production and lamb traits. J. Anim. Sci. 47:89.

Levine, J.M. and W.D. Hohenboken. 1978b. Crossbred lamb production from Columbia and Suffolk ewes. II. Simulation of the sheep flock; net return per ewe. J. Anim. Sci. 47:97.

Lloyd, W.R., A.L.Slyter and W.J. Costello. 1981. Effect of breed, sex and final weight on feedlot performance, carcass characteristics and meat palatability of lambs. J. Anim. Sci. 51:316.

Makarechian, M., A.W. Munson, L.E. Walters and J.V. Whiteman. 1977. Some relationships between measures of growth and carcass composition in lambs. Oklahoma State Univ. and USDA Res. Rep. MP-101. p 120.

Makarechian, M., J.V. Whiteman, L.E. Walters and A.W. Munson. 1978. Relationships between growth rate, dressing percentage and carcass composition in lambs. J. Anim. Sci. 46:1610.

Mitchell, B. 1980. A study of the growth and carcass characteristics of large lambs. Anim. Breed. Abstr. 48:2515 (Abstr.).

More O'Ferrall, G.J. and V.M. Timon. 1977a. A comparison of eight sire breeds for lamb production. 1. Lamb growth and carcass measurements. Irish J. Agr. Res.

16:267.

More O'Ferrall, G.J. and V.M. Timon. 1977b. A comparison of eight sire breeds for lamb production. 2. Lamb carcass composition. Irish J. Agr. Res. 16:277.

Nitter, G. 1978. Breed utilisation for meat production in sheep. Anim. Breed. Abstr. 46:131.

Norman, L.M. and W.D. Hohenboken. 1980. Genetic and environmental effects of internal parasites, foot soundness and attrition in crossbred ewes. J. Anim. Sci. 48:1329.

Riley, M.L., R.A. Field and M.P. Botkin. 1972. The effects of breed and age on carcass traits of lambs. Proc. West. Sec. Amer. Soc. Anim. Sci. 23:86.

Rouse, G.H., D.G. Topel, R.L. Vetter, R.E. Rust and T.W. Wickersham. 1970. Carcass composition of lambs at different stages of development. J. Anim. Sci. 31:846.

Sents, A.E., D.L. Beerwinkle, J.V. Whiteman, L.E. Walters and J.E. Fields. 1980. Feed Efficiency and carcass characteristics of ram lambs born in three seasons and slaughtered at four weights. Oklahoma State Univ. Res. Rep. MP-107. p 31.

Shelton, M. and Z. Carpenter. 1970. The influence of sex, breed, and sire on certain traits in lambs. Proc. West. Sec. Amer. Soc. Anim. Sci. 21:339.

Shelton, M. and Z.L. Carpenter. 1972. Influence of sex, stilbestrol treatment and slaughter weight on performance and carcass traits of slaughter lambs. J. Anim. Sci. 34:203.

Solomon, M.B., J.D. Kemp, W.G. Moody, D.G. Ely and J.D. Fox. 1980. Effect of breed and slaughter weight on physical, chemical and organoleptic properties of lamb carcasses. J. Anim. Sci. 51:1102.

Southam, E.R. and R.A. Field. 1969. Influence of carcass weight upon carcass composition and consumer prefereance for lamb. J. Anim. Sci. 28:584.

Steele, K. and W.D. Hohenboken. 1972a. Relationships between live weight and feed efficiency in lambs. Proc. West. Sec. Amer. Soc. Anim. Sci. 23:455.

Steele, K. and W.D. Hohenboken. 1972b. Relationships between slaughter weight and carcass merit in lambs. Proc. West. Sec. Amer. Soc. Anim. Sci. 23:80.

Sutherland, T.M. 1965. The correlation between feed efficiency and rate of gain, a ratio and its denominator. Biom. 21:739.

Thomas, D.L., J.V. Whiteman and L.E. Walters. 1976. Carcass traits of lambs produced by crossbred dams of Finnsheep, Dorset and Rambouillet breeding and slaughtered at two weights. J. Anim. Sci. 43:373.

Thompson, J.M., K.D. Atkins and A.R. Gilmour. 1979a. Carcass characteristics of heavyweight crossbred lambs. II. Carcass composition and partitioning of fat. Australian J. Agr. Res. 30:1207.

Thompson, J.M., K.D. Atkins and A.R. Gilmour. 1979b. Carcass characteristics of heavyweight crossbred lambs. III. Distribution of subcutaneous fat, intermuscular fat, muscle and bone in the carcass. Australian J. Agr. Res. 30:1215.

Torres-Hernandez, G. and W.D. Hohenboken. 1979a. An attempt to assess traits of emotionality in crossbred ewes. Applied Anim. Ethology 5:71.

Torres-Hernandez, G. and W.D. Hohenboken. 1979b. Genetic and environmental effects of milk production, milk composition and mastitis incidence in crossbred ewes. J. Anim. Sci. 49:410.

Torres-Hernandez, G. and W.D. Hohenboken. 1980. Relationships between ewe milk production and composition and preweaning lamb weight gain. J. Anim. Sci. 50:597.

USDA. 1981. Standards for slaughter lambs, yearlings and sheep. Code of Federal Regulations. Title 7. Part 53B.

Vesely, J.A. and H.F. Peters. 1966. Feedlot performance of five breeds of sheep and their carcass characteristics. Can. J. Anim. Sci. 46:139.

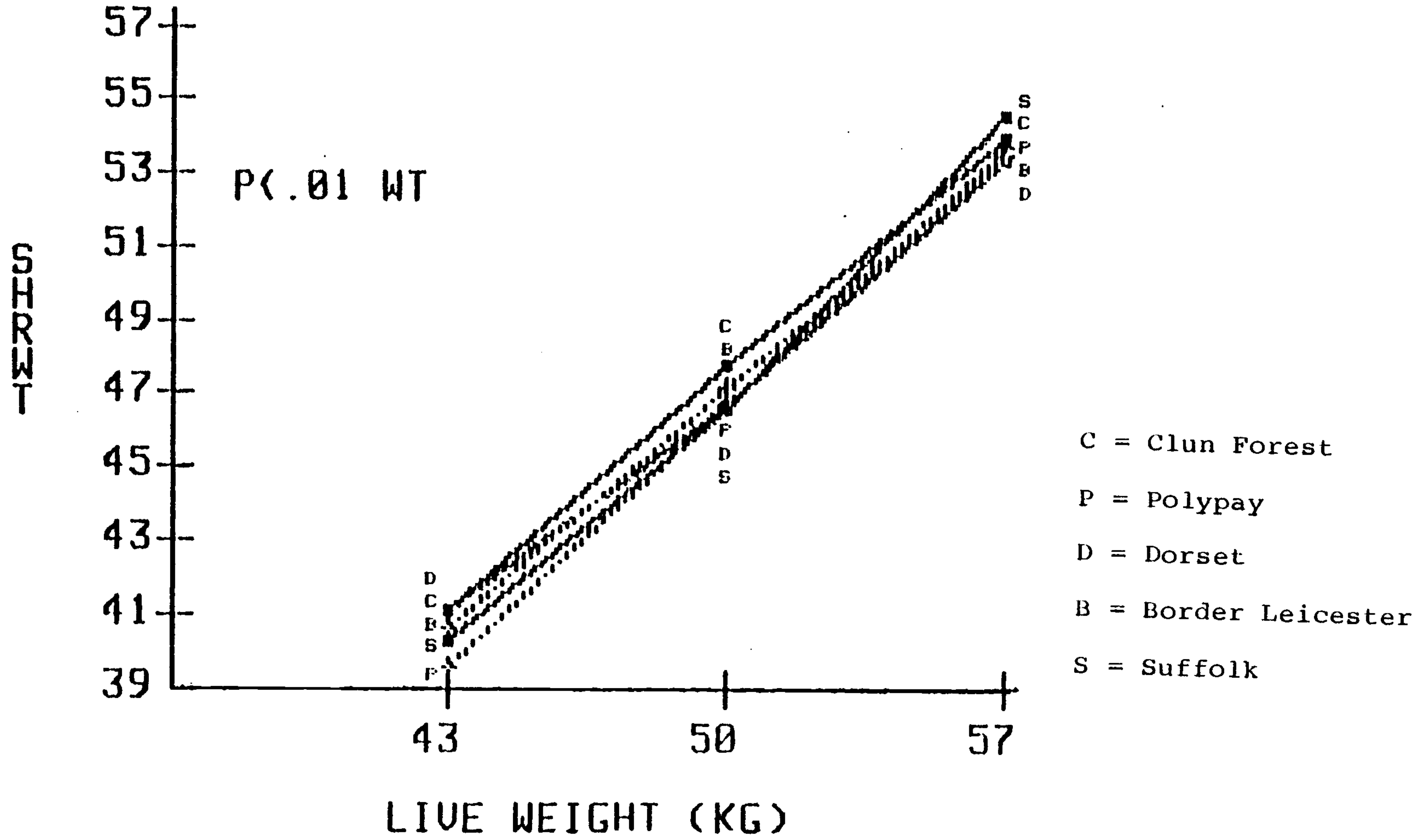
Vesely, J.A. and H.F. Peters. 1972. Muscle, bone and fat and their interrelations in five breeds of lambs. Can. J. Anim. Sci. 52:629.

Webster, A.J.F. 1977. Selection for leanness and the eneretic efficiency of growth in meat animals. Proc. Nutr. Soc. 36:53.

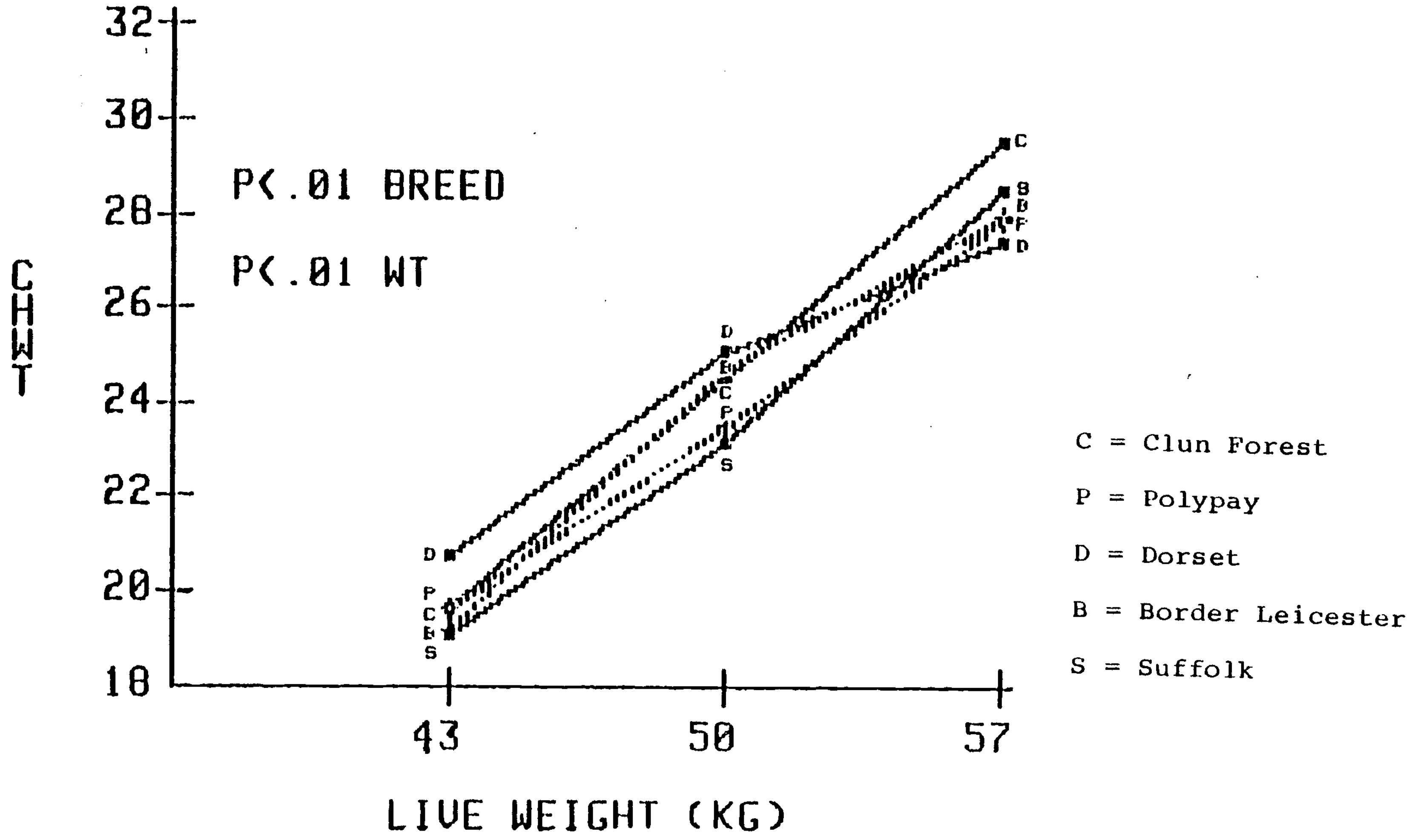
Wood, J.D. and H.J.H. MacFie. 1980. The significance of breed in the prediction of lamb carcass composition from fat thickness measurements. Anim. Prod. 31:315.

Wood, J.D., H.J.H. MacFie, R.W. Pomeroy and D.J. Twinn. 1980. Carcass composition in four sheep breeds: The importance of type of breed and stage of maturity. Anim. Prod. 30:135.

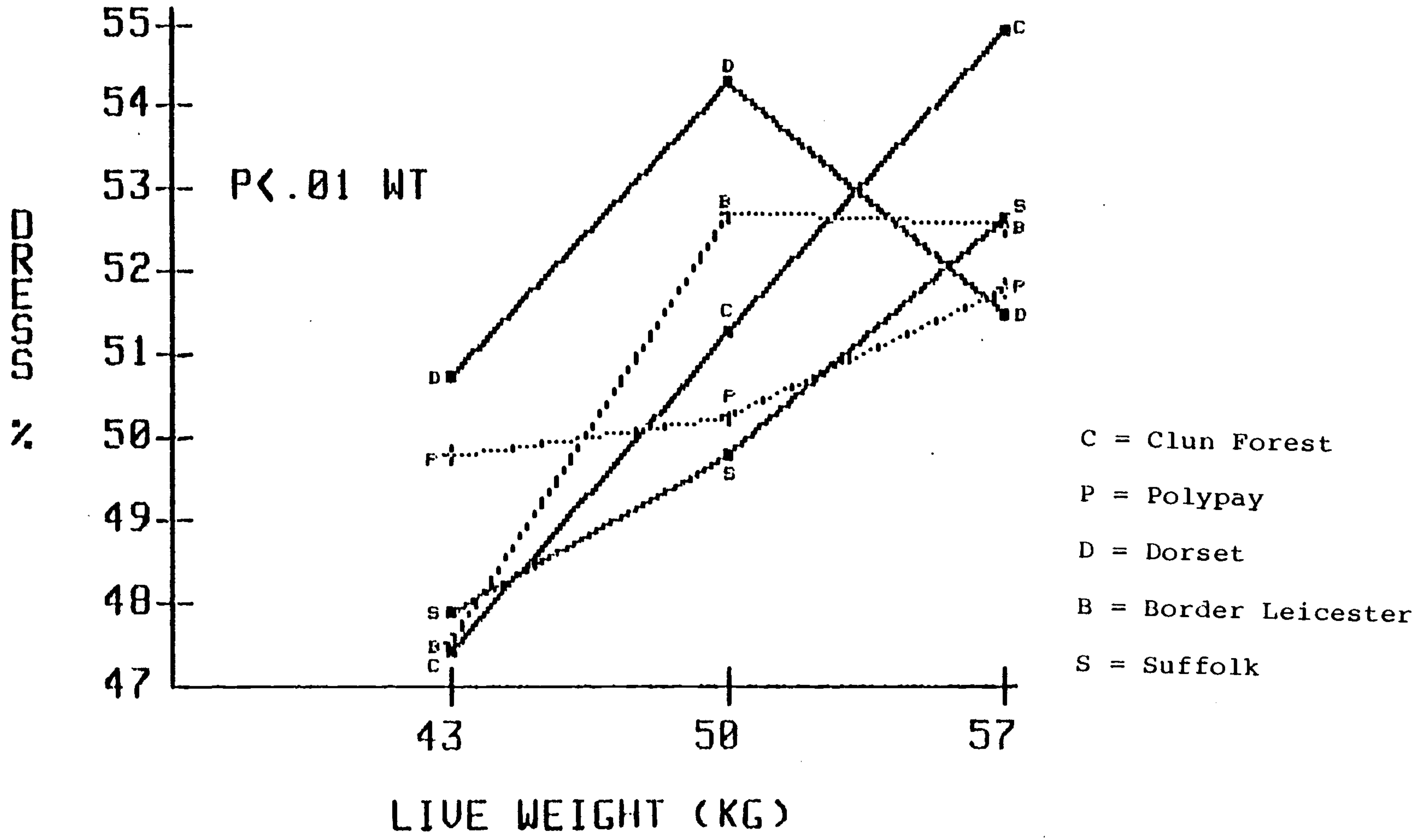
APPENDIX



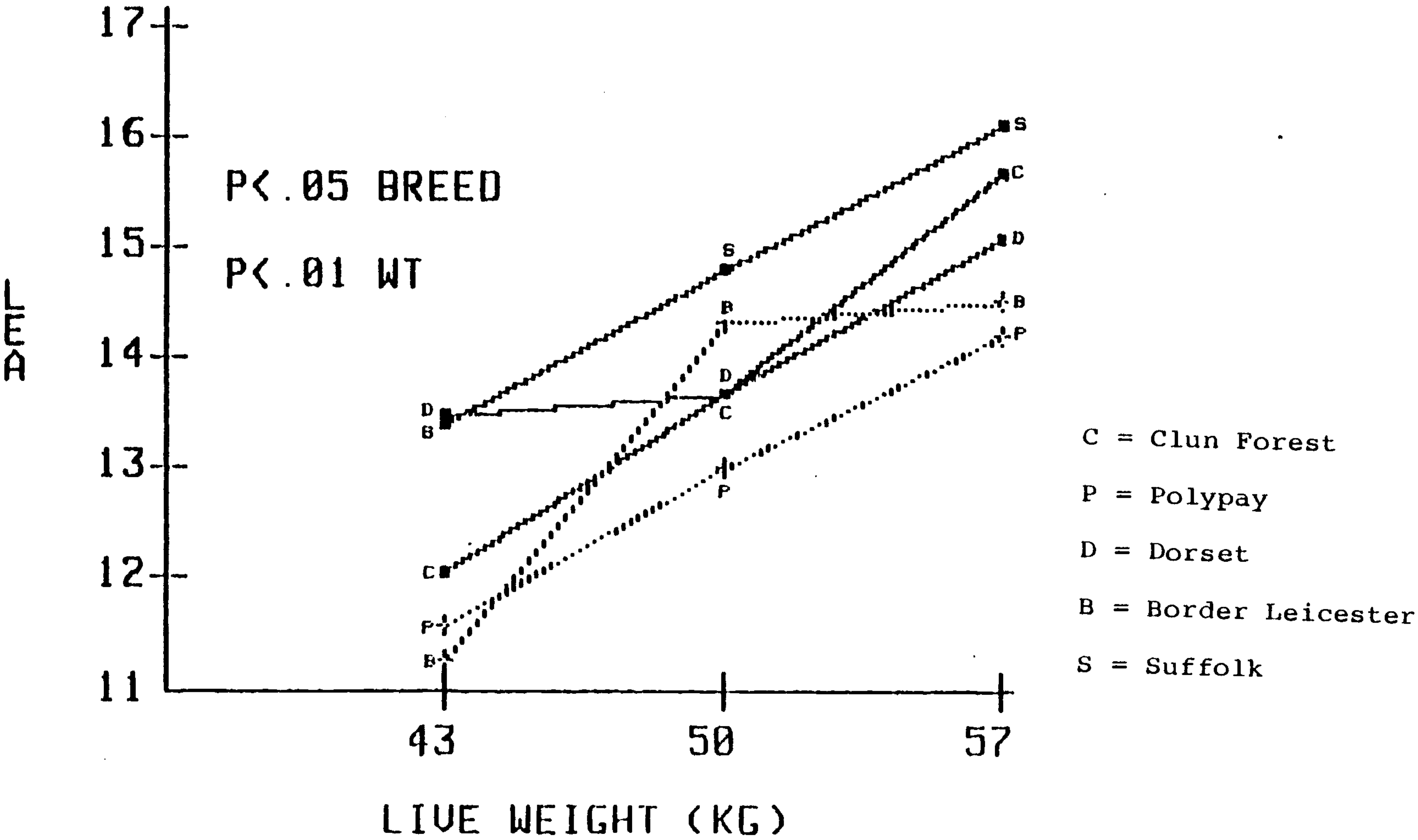
Appendix 1. Shrunk weight of group and individually fed lambs at three slaughter weights.



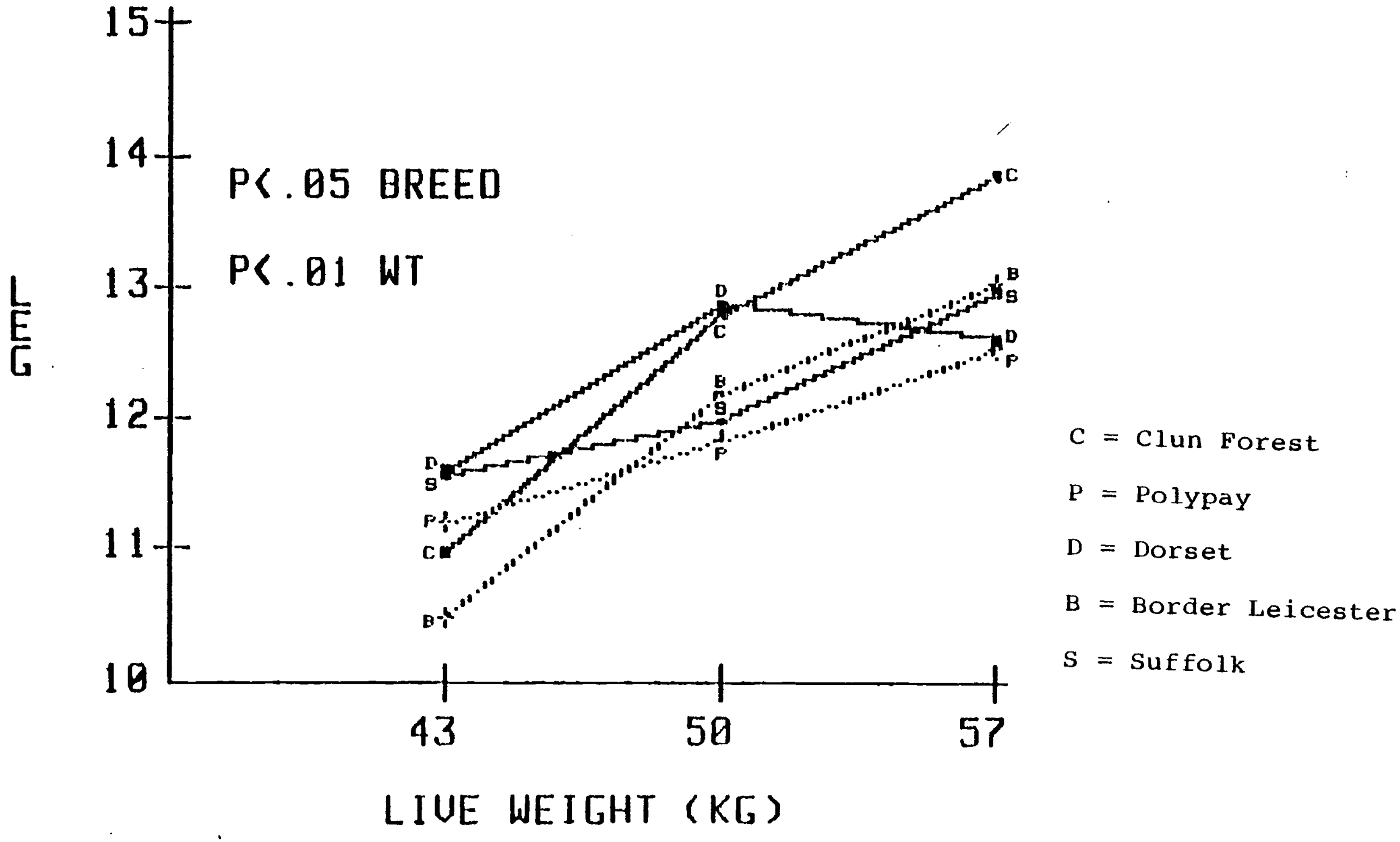
Appendix 2. Chilled carcass weight (kg) of group and individually fed lambs at three slaughter weights.



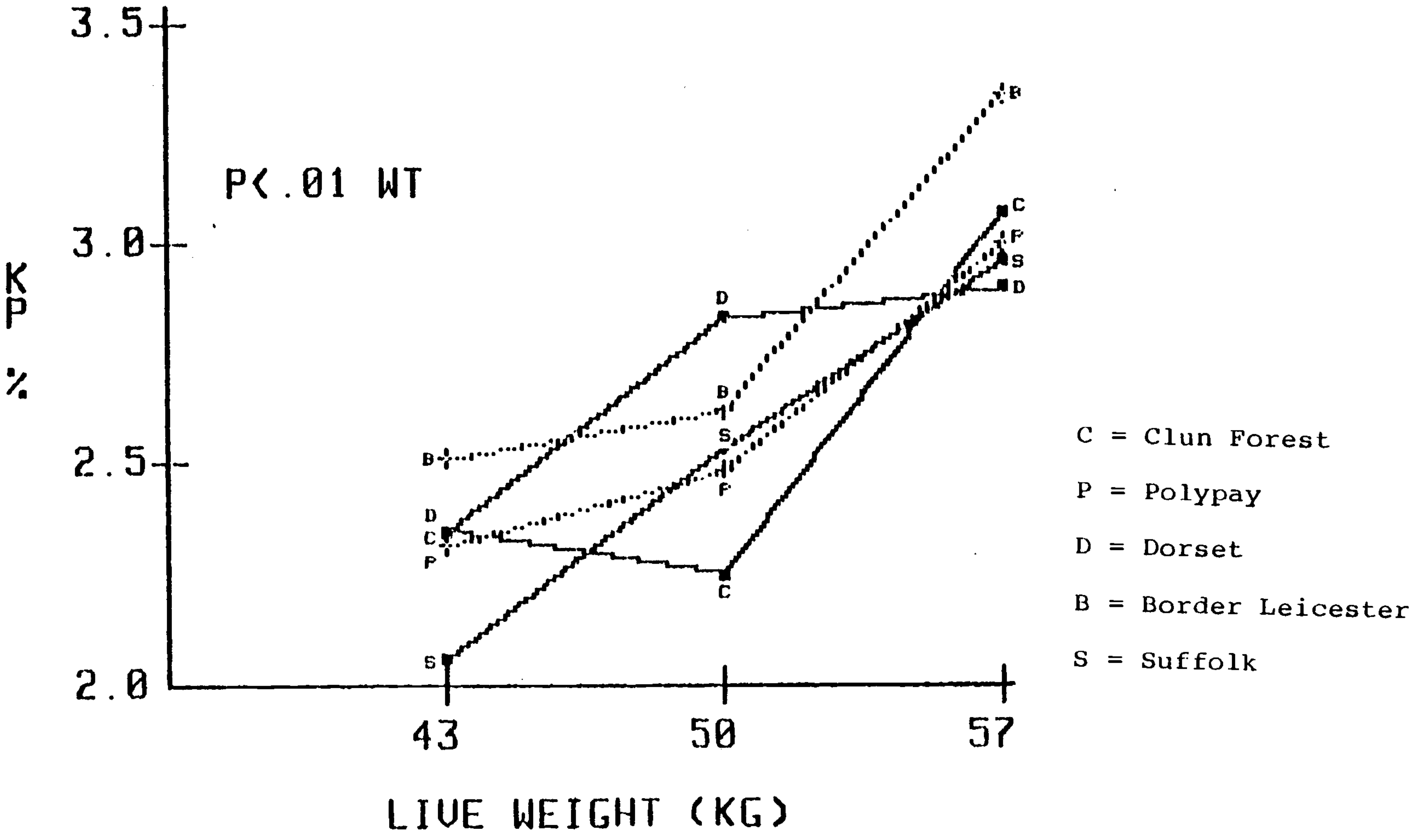
Appendix 3. Dressing percentage of group and individually fed lambs at three slaughter weights.



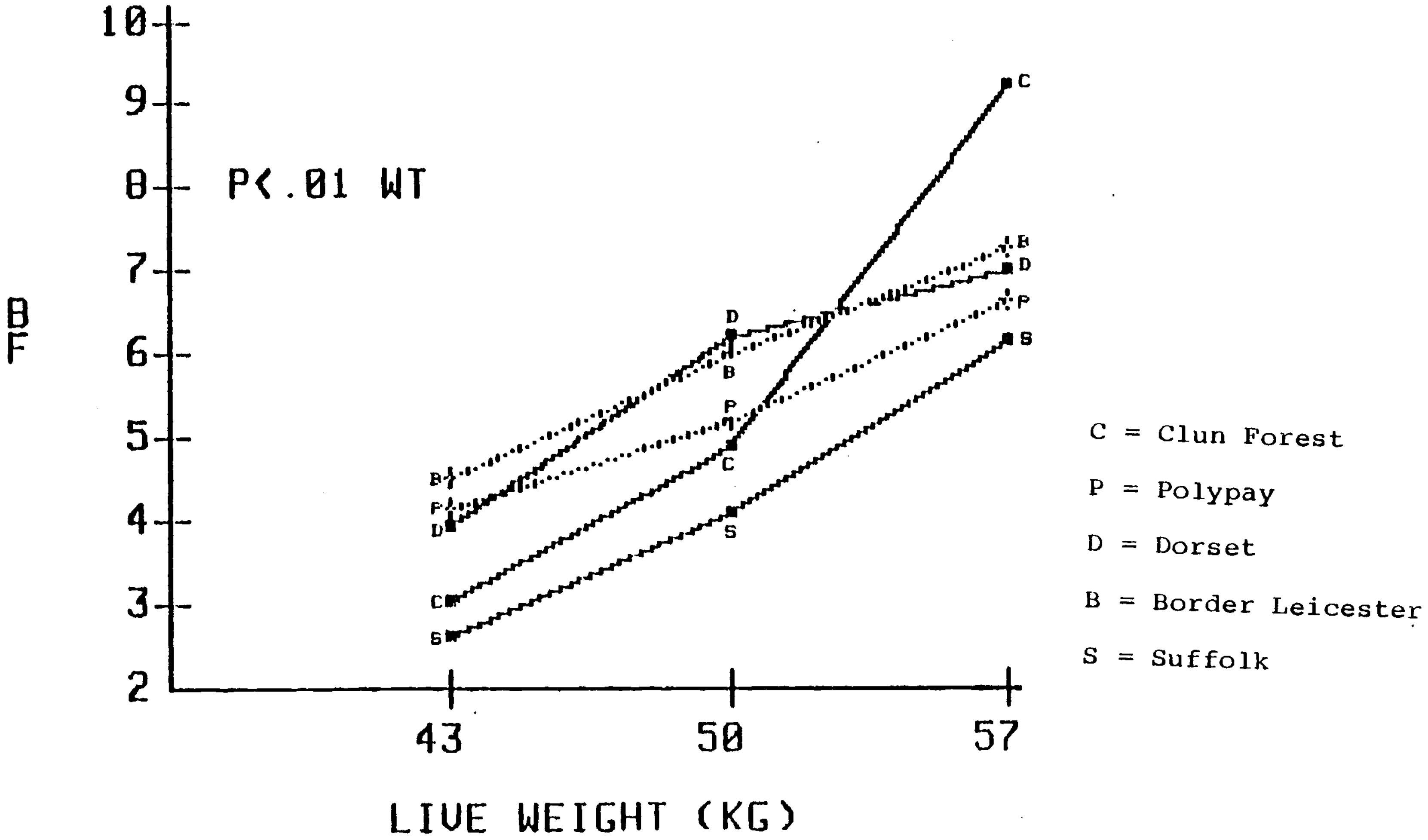
Appendix 4. Loin-eye area (cm^2) of group and individually fed lambs at three slaughter weights.



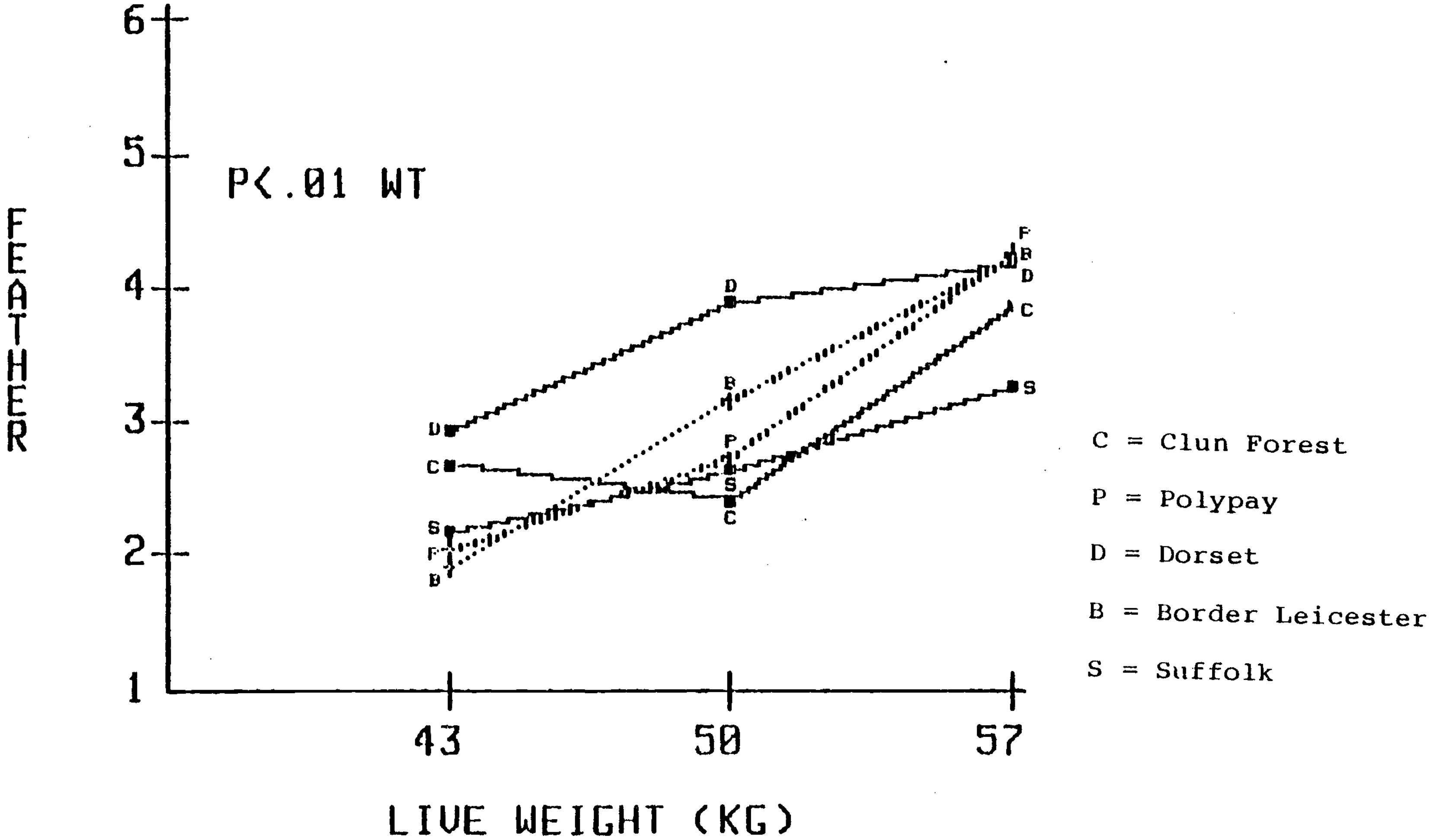
Appendix 5. Leg conformation score of group and individually fed lambs at three slaughter weights.



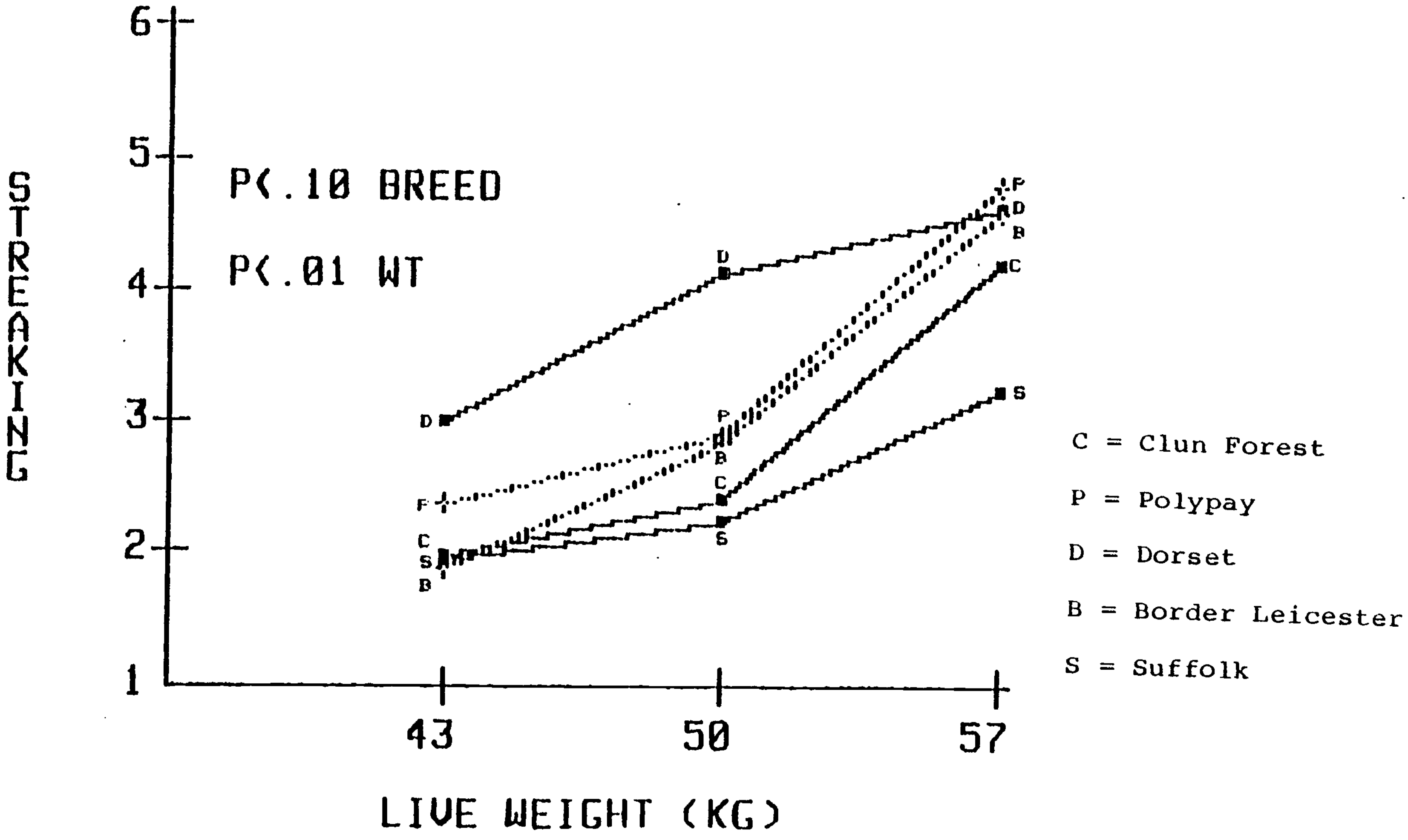
Appendix 6. Kidney-pelvic fat percentage of group and individually fed lambs at three slaughter weights.



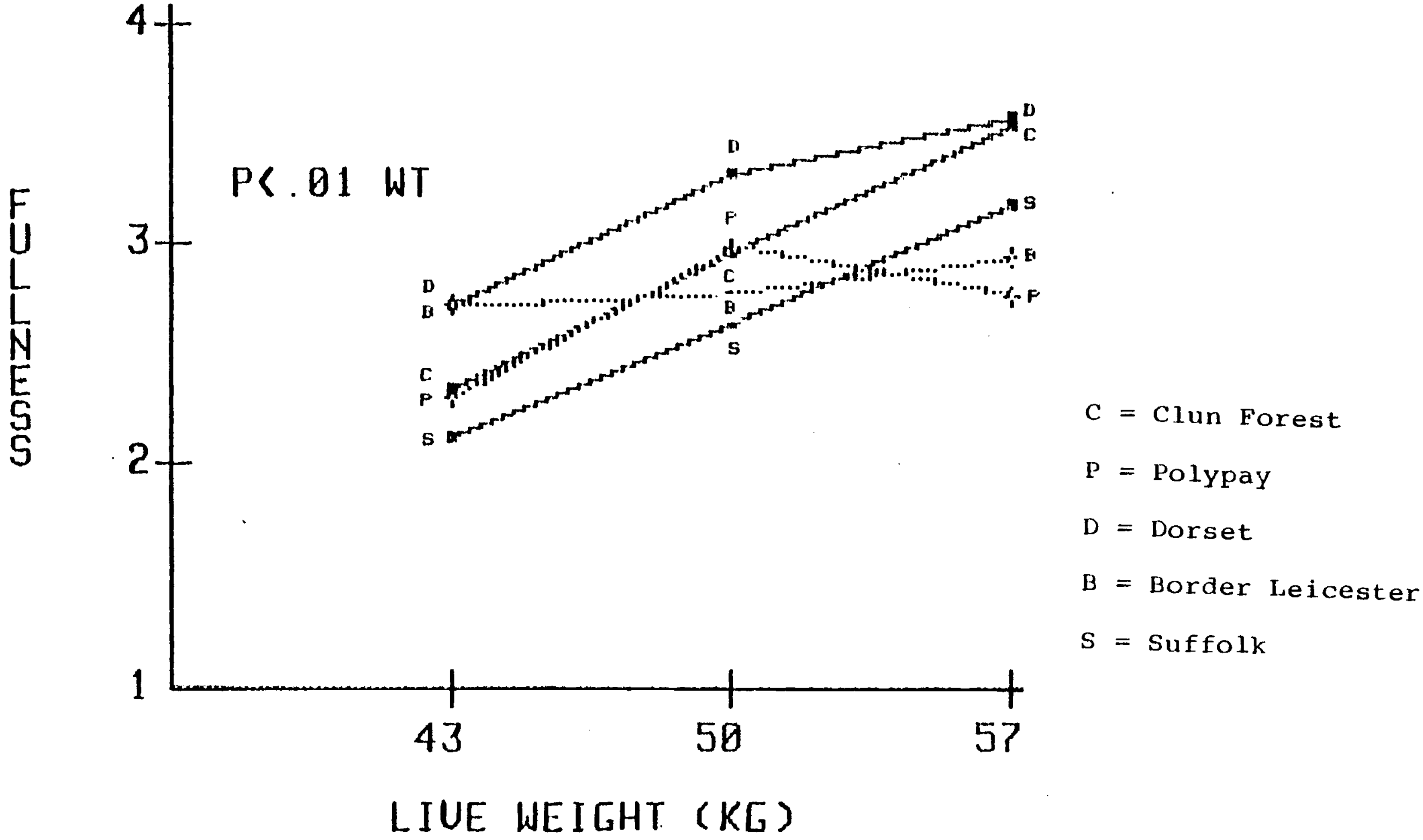
Appendix 7. Back fat thickness (mm) of group and individually fed lambs at three slaughter weights.



Appendix 8. Feathering score of group and individually fed lambs at three slaughter weights.



Appendix 9. Flank streaking score of group and individually fed lambs at three slaughter weights.



Appendix 10. Flank fullness score of group and individually fed lambs at three slaughter weights.