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A series of trials was conducted with Polypay (P), Coopworth (CP), Hampshire (H), and crossbred ewes over a two year period at three locations to assess the effects of ewe body condition and pre-lambing supplementation on ewe productivity. Supplementation trials were conducted at all three locations in Year 1 using P (OSU), CP (Farm 1), and crossbred ewes (Farm 2), and at OSU in Year 2 using P ewes. Supplementation consisted of one pound of whole corn daily in addition to the routine ration being fed to the controls. Supplementation began four weeks prior to lambing and continued to parturition. Body condition trials were conducted concurrently at OSU using CP, H, and crossbred ewes in the first year and CP ewes in the second year. A body condition trial was also conducted at Farm 1 (CP ewes) in the second year. At OSU, Polypay ewes were mated to CP, P, and H rams, CP ewes were mated to CP and H rams, and H ewes were mated to H rams. On the commercial farms, CP ewes (Farm 1) were mated to CP rams, and crossbred ewes (Farm 2) were mated to Suffolk rams.

Ewes in supplementation trials were condition scored on a five point scale(1=very thin; 5=very fat)at the time of allocation to

treatments six weeks pre-lambing, and ewes in all trials were scored one week prior to lambing. In addition, in Year 2 P and CP ewes at OSU were scored and weighed at mating, post-mating, mid-gestation, pre-lambing, and weaning. Production traits recorded included litter size at birth, total weight of lamb born (TWB), lamb survival, and individual lamb weaning weights (WWT). The various components were combined to calculate total weight of lamb weaned (TWW) by each ewe as the measure of total lamb production.

In most trials, higher ewe body condition score pre-lambing (CSL) was associated with heavier TWW. The heavier TWW was the result of both increased lamb survival and heavier individual lamb WWT. Supplementation increased both CSL and subsequent TWW; the increase in TWW was accounted for entirely through improved CSL. The response to supplementation was not consistent over ewe genotypes; crossbred ewes showed a greater increase in CSL than purebred ewes, and likewise a greater response in TWW.

While supplementation increased ewe productivity, a comparison of control vs supplemented ewes which were at the same body condition pre-lambing (CSL = 3.0) indicated that ewes which were previously thin did not perform as well as ewes which had been maintained in good condition throughout gestation. While supplementation raised their CSL to the same level, their lambs exhibited both lower survival and lighter WWT.

Comparison of the expense of supplementation with the increased TWW indicated a feed cost of about \$.30 per extra pound of lamb weaned. At typical lamb market prices of \$.60/lb, identification and supplementation of thin ewes pre-lambing would be a profitable management strategy for sheep producers.

# Effects of Body Condition and Pre-lambing Supplementation on Ewe Productivity

by

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## INTRODUCTION

Improving overall productivity in sheep has been a major concern of sheep producers. Reproductive efficiency of ewes, i.e. total weight of lamb weaned per ewe in the flock (Sidwell and Miller, 1971), is the most important factor affecting productivity and profitability in commercial sheep production systems in the United States (Sidwell and Miller, 1971; Dickerson and Glimp, 1975; Parker and Pope, 1983). Litter size (number of lambs born per ewe lambing) is a major component of reproductive efficiency (Bradford, 1972a).

Reproductive efficiency of ewes may be increased by improvements in management, genetics and or nutrition. The relationship between nutrition and reproduction in sheep has attracted considerable study. In general, an association between increased plane of nutrition before breeding and increased body fat has been found which leads to higher levels of reproduction (Coop, 1966a, 1966b). Subcutaneous fat is more highly correlated with percent of body fat than is intermuscular, mesenteric, or perirenal fat (Russel et al., 1971). Condition score based on palpation of the subcutaneous fat over lumbar vertebrae is more highly correlated with percent body fat than is body weight, although it is less repeatable (Russel et al., 1969). Body weight and condition score during the year has been shown to influence the onset of estrus, ovulation rate, fertilization rate, embryo survival, number of lambs born, dystocia, lamb survival, milk production and lamb growth.

In most sheep production systems pregnancy in sheep occurs in winter when nutrient availability is limiting or is of low quality. Based on results of earlier studies, producers try to keep their flocks in better condition at breeding to have higher litter size. Ewes with multiple fetuses use their body reserves to support their lambs during gestation, and in cases of limiting feed supply, lose body condition, resulting in lower lamb survival and total weight of lamb weaned.

The primary purpose of this study was to asses the effects of natural variation in body condition score on ewe productivity. The second purpose was to asses the effects of supplementation during late gestation on ewe productivity. The third purpose was to determine the optimum condition score at lambing, either due to late gestation supplementation or due to better condition at mid-gestation, on ewe productivity. Data from Year 2 trials conducted at OSU were used to examine the association between weights and condition score at various key periods of production and ewe productivity.

# CHAPTER 1

## LITERATURE REVIEW

Humans, animals and plants are the only living creatures on our planet and depend on each other for their survival. Ruminants have been exploited by people for their ability to convert the resources which are not in competition with human needs into useful products (meat, milk and wool). In many conditions sheep have a better rate of conversion of low quality foodstuffs than other domesticated ruminants and have a higher reproductive ability.

Reproductive ability is one of the most important factors determining the efficiency of animal production (Dickerson, 1970). This is particularly true for sheep (Large, 1970). The productivity of a ewe may be measured in a number of ways: (1) as the number of lambs born, (2) as the number of lambs weaned or (3) as the weight of lamb weaned per ewe mated or per ewe lambing (Sidwell and Miller, 1971; Dickerson and Glimp, 1975; More-O'Ferral, 1976; Parker and Pope, 1983; Lewis and Burfening, 1988). In some sheep production systems a single lamb weaned per ewe lambing only pays the maintenance cost, while an additional lamb weaned may increase income at little extra cost.

Reproductive efficiency may be increased by improvement in genetics, management, or nutrition/ body condition. Consideration of all these areas is beyond the scope of my thesis; therefore emphasis will be given to the interrelated effects of nutrition and body condition.

**Estimating Nutritional Status:**

Nutrition positively effects reproductive performance through several related factors including live weight, body condition and body size.

Live weight is a combination of body size and condition. Live weight of the ewe has been used to estimate the nutritional status of the ewe; however, due to difference in body size, nutritional status may vary among individuals of the same weight. Russel et al. (1969) and Ducker and Boyd (1977) concluded that ewe body condition is a better indicator of the nutritional status of the ewe than is live weight because body condition provides an acceptable and useful estimate of proportion of fat in the animal body.

Body condition score is a subjective estimate of fatness of the animal. The latest developing part of the growing animal is the loin. It is the last to put on fat and first to loose it. The condition status of sheep can be assessed by feeling the muscling and fat cover over and around vertebrae in the loin region (Jefferies, 1961; Greg, 1974). Condition scoring has been extensively used in Australia and Great Britain to improve ewe productivity. Body condition is usually scored on a scale of 1 to 5 (1= very thin and 5=very fat) as described by Jefferies (1961). Russel et al. (1969) amended the scoring method by including half scores to the scale. A three step method of condition scoring can be discribed as below.

**a:** Palpation of the prominence of the spinous process of the anterior lumbar vertebrae;

**b:** Evaluation of the sharpness and the degree of cover over the ends of the transverse process and the extent of the muscular and fatty tissue beneath them by spanning the lumbar vertebrae with fingers and thumb;

**c:** Appraisal of the depth of the Longissimus dorsi muscles and the degree of fat cover by palpating the region between the spinous and transverse processes.

Ewes of body condition 3.0 are average and have moderate fat cover over lion muscles. Spinous processes are felt as a straight line and transverse processes as smooth and rounded.

Body condition scoring is also used for beef cattle, with the scale typically ranging from 1 to 9 with 1 being very thin and 9 being extremely fat (Herd and Sprott, 1991; Veserat et al., 1991). It is assessed in beef cattle solely by visual appraisal of the animals.

Body fat is generally regarded as a concentrated reserve of energy which may be mobilized during periods of undernourishment. Subcutaneous tissues, omental and mesentery tissues, intra-muscular fat, perirenal fatty tissue, and pericardial tissue are sites of fat deposition in sheep. The relative amount of fat at these sites varies with the genotype. Mountain sheep breeds tend to have less subcutaneous and more intermuscular fat than Down and Border Leicester crosses (Palsson, 1940). Fat deposition in the body differs at different times of the production cycle. Sykes (1974) reported less body fat in blackface ewes slaughtered after weaning than those slaughtered at mating. Body reservoirs of energy are utilized by ewes during the period of undernourishment in pregnancy. During early gestation, loss of maternal tissue is very small but in late pregnancy the fat loss increases considerably (Russel et al., 1968).

Subcutaneous fat is more highly correlated with percent body fat than is intermuscular, mesenteric or perirenal fat (Russel et al., 1971). Although body condition scores have lower repeatability compared to live weight, body condition score based on palpation of subcutaneous fat is more highly correlated with percent body fat than is body weight (Russel et al., 1969). For ewes of similar body size, Russel et al. (1969) reported a mean weight difference of 10 kg per unit difference in condition score. The optimum score for commercial ewes under most conditions is 3.0; this corresponds to about 30 percent of fat in the fleece free empty body (Russel et al., 1969; Russel et al., 1971; Robinson, 1987).

The proportion of water in the fat-free body of poor body condition ewes is greater than for good body condition ewes (Foot et al., 1979). This indicates that ewes in thin condition have less fat in their body than ewes in good condition. During gestation fat is mobilized by ewes to meet the greater demand of energy by fetuses.

Feed intake is regulated by several factors including age and body condition. Intake of mature sheep has been shown to decline when the amount of body fat reaches 30 % of their live weight; bycomparison, intake of young ewes was not affected by the same level of fatness (Graham et al., 1991). Farrell et al. (1972 a; 1972 b) reported higher total daily energy expenditure at pasture by thin ewes as compared to ewes in good body condition. Foot (1972) and Arnold and Birrell (1977) reported higher intake of adult ewes in poor condition compared to fat ewes; however, when Donelly et al. (1974) compared mature ewes in poor, good and better body condition on three planes of nutrition under housed conditions; they foundpoor condition ewes had lower feed intake than ewes in better condition.

Feed intake also varies with the physiological state of sheep. Arnold (1975) reported higher feed intakes in pregnant and lactating ewes than in dry ewes.

Ewe body condition has been related to feed intake, sward height, and herbage mass of the pasture. Milne et al. (1986) reported that additional supplementation of high energy diet is necessary to meet the ewe's requirement of metabolizable energy while grazing on pasture of 3.5 cm, 3 cm and 2.5 cm sward height, respectively. Ewes kept on pastures of sward height of 3.5 cm had better body condition than ewes kept on pastures of sward height 3 cm or 2.5 cm (Gunn et al., 1991a, 1991b; Gunn et al., 1992a).

Sheep grazing on pasture of short sward height during the year may result in short term decrease in body condition. These losses in condition may be prevented by management practices such as supplementation with a high energy diet or reduction in stocking rate.

**Effects of Body Condition:**

It is well documented that ewes of body condition 3.0 or 3.5 (good body condition) have higher body reserves and give better reproductive performance than ewes of body condition 2.5 or lower (poor body condition). Reproductive performance of ewes in poor condition can be improved by giving them better nutrition. Body condition scoring enables feeding to be more accurately matched to the requirement of the ewe throughout the year (Pollott and Kilkenny, 1976). Ewe body condition and body weight during the year have been shown to influence ovulation rate (Coop and Clark, 1969; Meyer, 1985), conception rate (Wallace, 1961; Taplin and Everitt, 1964; Nordby et al., 1986), embryo survival (West et al., 1991) litter size born (Coop, 1966b; Gunn et al., 1991b), lamb survival (Johnson et al., 1982; Berggren-Thomas, 1984; Nawaz et al., 1992a, 1992b), milk production (Gibb and Treacher, 1980), and lamb growth (Berggren-Thomas, 1984; Nawaz et al., 1992a, 1992b). However, as reported by Williams et al. (1974) managemental practices which alter live weight or body condition appear to have no effect on the onset of the breeding season.

**Ovulation rate:**

Ovulation rate (number of ova shed per estrus) is the primary factor limiting litter size (number of lambs born) (Bradford, 1972a). Ovulation rate is affected by season of mating, age, genotype of the ewe and nutrition (ewe body condition).

In the Northern Hemisphere, ovulation rate increases from the commencement of the breeding season (August) and reaches a peak in September to November followed by a decrease towards the end of the breeding season (December and January) (Shelton and Morrow, 1965; Fletcher et al., 1970; Hulet et al., 1974; Newton, et al., 1980; Aboul-Naga, et al. 1987; Al-Mauly et al., 1991). Finn ewes, Booroola Merino ewes, and their crosses with other breeds tend to have higher ovulation rates than other breeds of sheep (Dickerson and Laster, 1975; Davis and Kelly, 1983; Amir and Gacitua, 1985; Meyer, 1985; Aboul-Naga et al., 1985; Fahmy and Dufour, 1988; Piper et al., 1988; Meyer and Piper, 1992). Mature ewes have higher ovulation rate than younger ewes (Cedillo et al., 1977; Meyer, 1985; Fahmy and Dufour, 1988; Lewis and Burfening, 1988; Meyer and Piper, 1992; Meyer et al., 1993a).

Flushing is defined as provision of an improved diet for about 3 weeks before mating to ewes in fairly poor condition at breeding time to improve their reproductive performance (Rickets, 1970) and its effects are well documented (El-Sheikl et al., 1955; Wallace, 1961; Coop, 1962; Coop, 1966a, 1966b; Edey, 1966; Killeen, 1967; Edey, 1968; Gunn et al., 1969b; Cumming et al., 1972; Meyer and Bradford, 1973; Cumming et al., 1975 ; Gunn and Doney, 1975; Bramley et al., 1976; Gunn, 1979; Newton et al., 1980; Knight and Hockey, 1982; West et al., 1991; Forcada et al., 1991; Gunn et al,. 1991a; Gunn et al,. 1992b; Haresign, 1992a, 1992b). Ewes in good body condition (CS 3 and above) at breeding generally tend to have higher ovulation rates than ewes in poor body condition. Rhind et al. (1984b) examined Grey-face ewes in moderately good condition (mean score 2.75) and fat condition (mean score

3.5) and found them to have mean ovulation rates of 2.33 vs 3.36, respectively. In another study, Gunn et al. (1969b) reported lower ovulation rates of Scottish Blackface ewes in body condition 1.5 vs 3.0. Gunn and Doney (1979a) in a similar study compared the ovulation rates of Cheviot ewes of mean condition score 2.0 vs 3.0 and reported higher ovulation rates in ewes of better body condition than ewes of poor body condition (2.03 vs 1.61).

Gunn et al. (1969b) reported the existence of a band of pre-existing body condition (CS 1.5 to 2.0 prior to flushing) at which ovulation rate was increased by flushing.

Higher conception rates for ewes of better condition at mating have been reported by many researchers (Coop, 1962; Coop, 1966b; Meyer and Bradford, 1973; Gunn et al., 1990a; West et al., 1991).

**Gestation:**

It has been well documented that undernutrition of ewes during pregnancy limits the growth and development of the fetal lamb (Wallace, 1948a,b; Alexander, 1964a; Taplin and Everitt, 1964; Everitt, 1967a, 1967b; Cumming et al., 1972; Cumming et al., 1975; Mellor, 1981; Mellor, 1982; Robinson, 1983; Croker et al., 1990; Mellor, 1990) resulting in lambs of lighter birth weight, increased fetal and lamb mortality, weaker lambs and decreased lamb growth rate (Alexander, 1964; Nordby et al., 1987).

The 21 week gestation period in sheep can be divided into three stages with maternal nutrition requirements varying between the stages. The first stage, from conception to 30 days, consists of the pre-implantation (days 0 to 15) and the implantation phases (days 16 to 30). A balance between embryo numbers occurs in the two uterine horns of multi-ovulating ewes during the pre-implantation phase. The implantation phase is characterized by a progressive strengthening of bonds between the cotyledons (the fetal components of attachment), and the uterus (Robinson, 1983).

The second stage, mid-gestation (days 30 to 90) is characterized by rapid growth of the placenta while fetal growth is relatively minor (Mellor, 1990). The third and final stage is late gestation (days 90 to parturition), characterized by major gain in mass of the fetus. Gain in fetal mass in the last 8, 4, and 2 weeks of gestation is equivalent to 85, 50 and 25 % of fetal birth weight (Robinson et al., 1977 and Mellor, 1990).

**a. Early gestation nutrition:**

During early gestation (pre-implantation), the critical factor affecting ewe productivity is embryonic loss, i.e. failure of fertilized ova. Many pre-mating factors affecting ovulation rate are believed to also have an effect on embryo survival. Post-mating factors include stresses due to disease, the environment, or nutrition. The latter could be easily controlled by the producer. Sheep embryos appear to be sensitive to maternal nutrition during the early stage of pregnancy even though their requirements for nutrients are less than those of fetuses in mid to late gestation (Coop, 1966b; MaCkenzie and Edey, 1975; Milne et al., 1986; Robinson, 1987; Mellor, 1990; Gunn et al., 1990b; Gunn et al., 1991 a, 1991 b; West et al., 1991; Gunn et al., 1992b).

Ewes in poor condition at mating have more embryonic losses (Guerra et al,. 1971a, 1971b; Gunn et al., 1972; Gunn and Doney. 1975; Cumming et al., 1975; Edey, 1976; Gunn and Doney, 1979; Al-Nakib et al., 1986; Gunn and Maxwell, 1989).

Embryo survival varies among ewe genotypes. West et al. (1991) examined the effects of body condition and post-mating nutrition on embryo survival in Polypay and Coopworth x Polypay crosses and reported that embryo survival depends on ovulation rate and ewe body condition at mating. Low post-mating nutrition did not effect fetal survival in twin-ovulating ewes but reduced survival in triple-ovulating ewes. Coopworth crosses had higher embryonic loss than straightbred Polypay ewes. Higher embryo survival in ewes on better nutrition has also been reported by Meyer and Bradford (1973). Better embryonic survival for crossbred ewes than for purebred ewes have been reported by many researchers (Foote et al., 1959; Meyer and Bradford, 1973; Cumming et al., 1975, Nawaz and Meyer. 1991; Nawaz et al., 1992b).

During early gestation, the embryo gets nourishment directly by absorption of fluid from its environment in the uterus (Croston and Pollot, 1985). Some researchers have found embryonic losses in ewes fed high or low levels of nutrition at mating (Casida, 1964; Edey, 1976; Robinson et al., 1977; Doney, 1979). Doney (1979) reported that overfeeding may result in increased embryonic losses but the magnitude and significance of the effect depends on interaction with pre-mating nutrition, ovulation rate and ewe genotype. Coop and Clark (1969) and Robinson (1987) suggested that ewes may be kept slightly undernourished during early gestation so feed may be conserved for use in late pregnancy.

Nutrition may affect productivity through its influence on various hormone concentrations. Good nutrition tends to increase plasma progesterone concentrations, which researchers believe to be responsible for the rapid pre-implantation growth phase of embryos during days 11 to 15 of pregnancy (Bindon, 1972; Cumming et al., 1972; Parr et al, 1982; McMillen et al., 1991).

Embryonic losses during the implantation phase are believed to result mainly from nutritional stress (Rhind et al., 1980; McDonald et al., 1981). Early embryonic loss tends to disturb the balance in the distribution of the fetuses between the uterine horns. Surviving embryos cannot utilize the maternal cotyledons vacated by the dead embryo and results in reduced birth weight. Ewes facing severe nutritional stress during this period have been reported to have increased embryonic loss and loss of maternal body weight (Taplin and Everitt, 1964; Currl et al., 1975; Nordby et al., 1987).

**b: Mid-gestation nutrition:**

Undernutrition during mid-gestation greatly affects placental growth as compared to fetal growth (Robinson, 1987). The placenta in ewes grows at a rapid rate beginning at four weeks of gestation and attains maximum weight at 13 weeks of gestation, after which its weight is unchanged until parturition (Barcroft and Barron, 1946; Mellor, 1983). The placenta is attached to the uterus at specific uterine sites called caruncles. A placentome of maternal and fetal tissue develops at this site and the fetus gets its nutrition through maternal blood flow. Reduction of blood supply to the fetus initiates short-term responses such as increased fetal glucose mobilization and reduction in oxygen consumption by the fetus (Mellor, 1990). Robinson (1987) recommended that ewes be maintained at a condition score of 3.0 during mid-gestation.

Maternal undernutrition during mid pregnancy has been reported to either retard (Everitt, 1964) or increase (Robinson, 1987; McCrabb et al., 1992) placental growth. Maternal undernutrition during mid pregnancy has been reported to result in lambs of lower birth weight (Curll et al., 1975; Rattray et al., 1979; Russel et al., 1981; Mellor 1983; Nordby et al., 1986). A live weight increase of 10 kg in ewes has been reported to increase lamb birth weight by approximately 0.5 kg. (Currl et al., 1975; Scales et al., 1986).

During mid-gestation, ewes in good body condition at mating can obtain an adequate intake of energy from ad libitum feeding of low quality roughage containing 7 to 8 MJ of metabolizable energy/kg dry matter (Robinson, 1987). It is necessary that the roughage contain enough nitrogen to achieve adequate synthesis of microbial protein in the rumen. Russel et al. (1981) compared the effects of two levels of nutrition (low and high) during mid-pregnancy (38 to 98 days of gestation) on birth weight of lambs from ewes of varying size, weight and condition at first mating. High plane was given to maintain weight during mid-gestation while the low plane was given to induce a maternal weight loss of 6 kg, assuming the gravid uterus and its contents would weigh about 3 kg. The ewes on the high plane of nutrition had intake twice as much food during mid-pregnancy as the ewes on the low plane. The ewes on low plane of nutrition had lower lamb birth weights than the ewes of high plane of nutrition. McCrabb et al. (1992) reported reduction in both placental growth and fetal weight as a result of maternal undernutrition during mid-gestation.

**C: Late gestation nutrition:**

Late gestation nutrition is important for the health of both ewe and fetus. The effects of late gestation nutrition on lamb birth weight and lamb survival are well documented (Alexander, 1964; Robinson et al, 1977; Hohenboken, 1977; Russel et al., 1981; Robinson, 1983; Beeston, 1984; Gunn et al., 1986; Scales et al., 1986; Holst et al., 1986; Jordan and Mayer, 1989; Hohenboken et al., 1988; Wilkinson and Chestnutt, 1988). Ewes suffering sever heat stress during mid-and late pregnancy had been reported to have low birth weights (McCrabb et al. 1993).

The condition of ewes during mid pregnancy influences the partitioning of nutrients for fetal growth in late pregnancy. Pre-lambing provision of high planes of nutrition to ewes underfed in mid gestation helps in improving body condition and live weight (Wilkinson and Chestnutt, 1988). Provision of better nutrition during late gestation to ewes suffering nutritional restriction helps in compensating fetal growth and development (Taplin and Everitt, 1964).

Age of the ewe is an important factor in determining the necessary level of nutrition in late gestation. Younger ewes are more sensitive to nutritional stress than older ewes. Robinson et al. (1977) reported a study of undernutrition of mature and young ewes in mid pregnancy followed by good feeding in late gestation. Good feeding in late gestation resulted in partial compensation in fetal growth of lambs; however, young ewes were less capable of compensating than were mature ewes. Rattray et al. (1979) reported that mature ewes undernourished during mid-gestation can completely compensate for fetal growth if given high levels of feeding during late gestation. Ewes in poor condition at the end of the first month of gestation with a litter size of two or more have less chance of compensatory growth by feeding high levels of nutrition than ewes of poor condition in late gestation (Robinson, 1983).

Chronic undernutrition during late gestation reduces lamb birth weight by slowing down prenatal growth (Rattray et al., 1974; Mellor and Murray, 1981 and 1982). Mellor and Murray, (1981) reported as much as 40 to 47 percent decrease in growth rate of fetuses from ewes undernourished in late gestation. Mellor and Matheson (1979) determined in vivo estimates of the daily changes in the curved crownrum lengths of individual fetuses and reported that sudden, severe restriction of feed intake around 115 days of gestation can reduce fetal growth by 30 to 40 percent within three days and may result in complete cessation of fetal growth. In their study, two groups of ewes were fed normal (NRC) or restricted diets two weeks before lambing. Lambs of lower birth weight born to underfed ewes had retarded growth rate and took three years to reach puberty.

Poor condition ewes have insufficient body fat to adequately nourish multiple fetuses during gestation. Late gestation supplementation to poor condition ewes have been shown to increase compensatory growth of their lambs. Beeston (1984) reported that lambs from ewes on a high plane of nutrition were 5% heavier at birth and 13% heavier at weaning than lambs from ewes on a low plane of nutrition. Total weight of lamb born for lambs born as twins and triplets were 26 and 44% heavier at birth than lambs born as singles; however, due to compensatory growth, difference at weaning was reduced to 7 and 12%, respectively.

Holst et al. (1986) provided high or low levels of nutrition to ewes during the last six weeks of gestation. The nutritional treatments resulted in significant differences in birth weight of twin lambs compared to single lambs. Survival of twin lambs was lower for ewes on the low plane of nutrition as compared to twin lambs born to ewes on the high plane of nutrition. There was no effect of nutrition on survival of lambs born as singles. At 16 weeks, lambs from ewes on the high plane of nutrition weighed 2 kg more than the lambs from ewes which had been on the low plane of nutrition. Berggren-Thomas, (1984) reported that lambs from ewes of good body condition at lambing were heavier at weaning than lambs from ewes in poor condition.

Late gestation supplementation also effects milk yield of ewes. Aguilera et al. (1992) and Rhind et al. (1992) reported higher milk yield for supplemented ewes during late gestation than unsupplemented ewes. Treacher (1971) fed two planes of nutrition to ewes in the last 6 weeks of pregnancy to get high and low gains in weight. He reported that ewes making low weight gains in late pregnancy produced lambs with a lower birth weight and had lower milk yield than those making high gains. Jordan and Hanke (1991), studying the effects of levels of energy and body condition changes during late gestation and early lactation, reported no difference for lamb birth weight, survival, milk yield, or weight of lamb at 30 days; however, the ewes in their trial had higher initial mean body condition than those in Treacher's study.

Ewes of mean pre-lambing body condition (2.4 and 3.2) bearing twin lambs were grazed at high and low stocking rates. Milk yields and lamb growth tended to be higher for ewes of better CS (3.2 vs 2.4). Slen and Whiting (1952) reported that a low level of protein intake during the last six weeks of gestation resulted in lighter lamb birth weights, higher ewe mortality and lower milk yield.

Some studies have shown no increase in milk yield or lamb growth as a result of late gestation supplementation. Slade (1980) fed two levels of nutrition to ewes during the last seven weeks of gestation. Ewes on good feed gained 5.2 kg more live weight as compared to ewes on low quality feed; however, there was no difference between the two treatments in birth weight of lambs or their subsequent growth rate to weaning. In a study, Gibb and Treacher (19-82) fed either the full energy requirement to maintain weight or fed to produce a loss of ewe body weight during the last seven weeks of pregnancy. Treatments applied during late gestation produced differences in ewe live weight and body condition scores at lambing; however, there were no effects on milk yield and lamb growth.

The first 72 hours after birth are especially important for lamb survival since the effect of weather and environmental factors are greatest at this time (Hight and Jury, 1970). The two important causes of neonatal mortality are dystocia and starvation/exposure (McFarlane, 1955; Jefferies and Fearn 1957; Alexander, 1964a, 1964b; Hight and Jury, 1970; Haughey, 1980; Dalton et al., 1980; Scales et al., 1986; Hussein and Jordan, 1990; Mellor, 1990). Lambs of lower birth weight or premature lambs have greater difficulty in survivingand the major cause of death is starvation/exposure (Alexander, 1964; Mellor, 1990). During the first 24 hours after birth, lambs use energy from body reserves and ingested colostrum to meet their requirements for heat production; inadequate intake or body reserves results in lamb mortality. (Alexander, 1964a, 1964b; Eales et al., 1982).

Ewes of better condition at lambing demonstrate better lamb survival (Rattray et al., 1979; Johnson et al., 1982; Skyes et al., 1982; Jordan and Feuvre, 1989). In a study, ewes with mean condition score of 2.1 at lambing had 80% lamb survival for twin lambs compared to single lambs. Mortality of twin lambs increases with the drop in ewe condition (King et al., 1990). Lamb survival is also influenced by ewe genotype. It is well documented that crossbred lambs have better survival than purebred lambs (Smith, 1977; Meyer et al., 1977; Fahmy, 1980; Oltenacu and Boylan, 1981a, 1981b; Hohenboken and Clarke, 1981; Magid et al., 1981; Cameron and Deeble, 1983; Donelly, 1984; Mann et al., 1984; Hulet et al., 1984; Saoud et al., 1984; Hossamo et al., 1985; Jordan et al., 1985; Lewis and Burfening, 1988; Fahmy and Dufour, 1988; Williams and Butt, 1989; Nawaz and Meyer, 1992; Nawaz et al., 1992b; Wiener et al., 1992; Meyer et al., 1993b).

Litter size has a substantial effect on lamb survival. Survival for lambs born as singles is better than for lambs born as twins as single lamb. Better survival of single lambs has been well documented in the literature (Sidwell et al., 1962; Sidwell and Miller, 1971; Smith, 1977; Oltenacu and Boylan, 1981b; Doney et al., 1983; Mellor, 1990; Nawaz and Meyer, 1992; Meyer et al., 1993b).

**d: Lamb weaning weights:**

Lamb weaning weight is affected by many factors including nutrition, breed, sex, litter size, rearing rank, age of dam, age of lamb, season, and management (Butterworth and Blore, 1969: Bradford, 1972b; Aboul-Naga et al., 1980; Oltenacu and Boylan, 1981a, 1981b; Robinson et al., 1980; Parker and Pope, 1983; Thomas and Dahmen, 1985; Lewis and Burfening, 1988; Nawaz and Meyer, 1992; Nawaz et al., 1992b).

Lamb growth is dependant upon the ewe's body condition at lambing. Ewes in good body condition at lambing due to either short term supplementation or better feeding throughout the year produce more milk and demonstrate better growth of their lamb. Gibb and Treacher (1980) examined the effect of ewe body condition at lambing on milk production and reported slightly higher milk yield from fat ewes than thin ewes. Slen and Whiting (1952) reported that low level of protein intake during the last six weeks of gestation lowers milk production in the first six weeks of lactation. The lower birth weight of an individual lamb in a litter of two or three is also a handicap for its growth, as it has to compete with the heavier lamb(s) for milk. Thomson and McDonald (1955) reported that a difference of one pound in birth weight of lambs resulted in three to four pounds difference in weaning weight. Within a homogenous group of ewes, lambs of heavier birth weight have been found to also be heavier at weaning (Everitt, 1967b; Murray and Selezacek, 1976). Meyer et al. (1993b) reported more weight of lamb weaned by crossbred ewes than purebred ewes.

Lactation in sheep is influenced by the plane of nutrition of the ewe and by the number of lambs suckling. Ewes suckling twins produce more milk than those suckling single lambs (Wallace, 1948a, 1948b; Doney and Munro,1961; Robinson and Forbes, 1968; Ricketts, 1970; Joseph and Foot, 1980; Torres- Hernandez and Hohenboken, 1980; Hinch et al., 1983; Munro and Geenty, 1983; Hinch et al., 1985; Thomas et al., 1988; McMillan et al., 1988; Dove and Milne, 1991; Rhind et al., 1992). The quantity of milk produced throughout lactation depends on the demand created by the number of lambs suckling in the first few days (Wallace 1948b); however, Davies (1959) stated that ewes giving birth to twins but rearing only one lamb from birth did not produce more milk than ewes rearing single lambs because of similar suckling reflex.

Geenty and Dyson (1986), reported factors affecting lamb growth and milk yield and concluded that lamb growth is dependent on milk supply during the first six weeks of lactation. Lambs begin to rely on forage and other supplement after six week of age. Lambs supplemented during preweaning period had higher weights at weaning than unsupplemented lambs (Chestnutt, 1992).

# CHAPTER 2

## EXPERIMENTAL PROCEDURE

A series of trials were conducted over two lambing seasons with several genotypes of ewes to determine the effects of pre-lambing supplementation and ewe body condition (CS) on total weight of lamb born (TWB), lamb survival, lamb weaning weight (WWT) and total weight of lamb weaned per ewe (TWW). An outline of treatments, genotypes and trial designation is given in Table 1. Apart from two cooperating commercial farms (one participating in both years and one in Year 1 only), all trials were conducted in the Sheep Research Unit of Oregon State University (OSU).

### Animals and Treatments:

#### Supplementation trials:

In Year 1, supplementation trials were conducted at OSU with Polypay ewes (Trial 1) and on two commercial properties (Trial 2, a registered Coopworth flock and Trial 3, a blackface crossbred ewe flock). Trial 1 ewes at OSU were mated with Hampshire (H), Polypay (P) and Coopworth (CP) rams. Trial 2 ewes were mated with Coopworth rams. Trial 3 ewes were mated with Suffolk rams. The ewes in these trials were selected from larger groups on the basis of being mated during the period of greatest mating activity and were randomly allocated within anticipated litter size (based on transabdominal ultrasound scanning during mid-gestation) into either control (C) or supplemented (S) treatment groups. The C groups received a modest amount of grain pre-lambing as per routine management for their respective management environments while the S groups received an additional daily allowance of 1.0 lb of whole corn beginning 4 weeks prior to initiation of lambing and continuing to parturition. Since lambing for these trials extended over 3 to 4 weeks, individual ewes may have been supplemented for as long as 7 to 8 weeks. Within each trial, all ewes were managed after lambing as a single group. All ewes in Trials 1 and 3, and Trial 2 S ewes were condition scored at the start of supplementation (CSI). Control ewes for Trial 2 were selected later from the rest of the flock by identifying unsupplemented ewes which had the same lambing date and birth rank as S ewes . All Trial 1 ewes (OSU) were scored one week prior to commencement of lambing and unlambed ewes were scored each week thereafter until they lambed. The condition score of each ewe at the weekly observation prior to lambing was considered as her condition score at lambing (CSL). A single pre-lambing scoring (CSL) of Trial 2 S ewes and all Trial 3 ewes was done one week prior to the start of lambing at each location.

Lambing in each of these trials continued for about four weeks with the majority of ewes in Trials 1 and 3 lambing in the first three weeks and the majority of Trial 2 ewes lambing in the last three weeks.

In Year 2, the OSU Polypay flock was again used for a supplementation trial (Trial 1a) with ewes mated to the same three ram breeds. Ewes were condition scored at pre-mating (CSB) in September, 1992, and were scored again when rams were removed after mating (CSP) in October. Condition scoring was repeated (CSI) on December 20, six weeks prior to initiation of lambing. Ewes with CSI of 2.5 or lower (64 of 114) were brought into the barn on January 2 and received daily supplement (S) of 1.0 lb whole corn in addition to hay until lambing. The remaining ewes (CSI of 3.0 or higher) remained on unsupplemented pasture (C) until being moved to the lambing barn one week before commencement of lambing. All ewes were condition scored one week before initiation of lambing and unlambed ewes were scored each week thereafter until they lambed; condition score at lambing (CSL) for each ewe was taken as her condition score at the weekly scoring immediately prior to lambing. The majority of ewes lambed in the first three weeks.

**Body condition trials:**

In Year 1, OSU ewes of several genotypes and Year 2 CP ewes at OSU and Farm 1 (as shown in Table 1) were condition scored under normal management conditions to determine the effect of naturally occurring variation in CS on the same production parameters as measured in the supplementation trials.

In Year 1, pre-lambing CS and subsequent production were measured in the OSU Coopworth (Trial 4), Coopworth x Polypay (Trial 5), Hampshire (Trial 6) and crossbred (Trial 7) flocks.

As with Trial 1 ewes, all ewes in each group were condition scored one week before the expected commencement of lambing, and unlambed ewes were condition scored weekly thereafter until they lambed. Condition score at lambing (CSL) was taken to be the condition score recorded at the weekly scoring preceding lambing.

In Year 2, Coopworth ewes were scored and weighed pre-mating (CSB), post-mating (CSP), mid-gestation (CSM) and prior to lambing (CSL). The flock is hereafter designated as Trial 4a and was comprised of the bulk of the Trial 4 ewes present in the previous year (less culls) plus replacements. In year 2, Coopworth ewes at Farm 1 (Trial 2a) were condition scored on March 10, 1992, one week prior to the start of lambing to measure the effect of pre-lambing ewe body condition on subsequent production.

Lambing continued for about six weeks with the majority of ewes lambing in the first four weeks.

**Lambing Management:**

All lambing of OSU trials occurred indoors. Flocks were moved into the barn according to their tentative lambing date and were scored at the time they moved into the barn. During the lambing period, ewes were under frequent surveillance and were assisted in cases of suspected lambing difficulty. Two to three hours after parturition each ewe and her offspring were moved to 1.75 $m^2$ pens where lambs were individually identified, weighed, vaccinated (Sore mouth and Pneumonia) and docked, and male lambs were castrated with an elastrator. Ewes were checked for milk production and litters of more than two lambs were reduced to two lambs of comparable size. Twin-bearers judged to have inadequate milk had their smaller lamb removed within 72 hours after birth. All removed lambs were regarded as dead for lamb survival analyses. Within three days of lambing, ewes with single lambs were combined in group pens of 8 to 10; ewes with multiple lambs were combined in group pens of 4 to 5 ewes per pen. Most ewes and their lambs went to pasture 5 to 7 days after lambing depending upon weather conditions. Lambs received routine vaccination (Enterotoxemia), and ewes and lambs were dewormed during the pre-weaning period. Lambs on the various trials were weaned and weighed at an average age of 10 to 12 weeks. Lambing at Farm 2 (Trial 3) occurred indoors but with less intensive management than at OSU. Lambing for Farm 1 (Trials 2 and 2a) occurred outdoors with only those ewes needing assistance being brought to a barn. Other lamb management practices were similar of those at OSU.

**Data Analysis:**

**Ewe and lamb data:**

Litter size at birth and total weight of lamb born and weaned per ewe lambing were analyzed separately for each trial using Analysis of Variance GLM procedures of SAS (1987). All main effects (condition scores, treatment group, birth rank, weaning rank, ram genotype) and their two way interactions were regarded as fixed, and weaning age or birth date was fitted, when appropriate, as a covariate. Main effect levels with few observations (generally < 8) were excluded from analyses. Interactions which were non-significant at P> .50 were omitted from final models. Lamb survival and weaning weights of individual lambs were analyzed by using similar procedures including lamb sex and genotype, where appropriate, in the models.

As mentioned in the description of lamb management, litters of more than two lambs were reduced to two and ewes bearing twins but judged to have inadequate milk had their smaller lamb removed within 72 hours after birth. All removed lambs were regarded as dead for lamb survival analyses. Live weight of taken in Trial 1a and 4a at five times during production cycle were analyzed by condition score and ewe age.

Correlation analyses were done to correlate ewe condition score at each time with subsequent condition scores, ewe condition score with adjacent CS, and condition score and body weights at each scoring for Year 2 trials conducted at OSU. Standard errors for correlation coefficients were calculated by the standard procedure described by Johnson and Kotz (1970).

# CHAPTER 3

## RESULTS

Numbers of ewe records available and those used for analysis of each trial are shown in Table 1. The distribution of ewe records analyzed for each condition score (CS) level in supplementation and body condition trials are given in Tables 2 and 3, respectively. Ewes which aborted, received grafted lambs or died during the trials were excluded from analyses.

Analyses of litter size at birth (Tables 4 and 5) indicate that in most of the trials, body condition at lambing (CSL) was not related to litter size at birth. Only Trials 1 and 1a (Table 4) showed a significant influence of CSL or ram breed on litter size at birth. Litter size averaged from 1.34 to 2.70 among various trials. Pre-mating condition score (CSB) had a substantial effect on litter size of Polypay and Coopworth ewes (Trial 1a and 4a; Table 5a). Polypay ewes (Trial 1a) had average litter size of 2.15 vs 1.78 for Coopworth ewes (Trial 4a).

**Supplementation Trials:**

**Trial 1 (OSU Polypay):**

**a. Lamb survival and growth:**

Lamb survival was significantly affected by CSL ($P<.001$). Ewes of CSL 3 and 3.5 had lamb survival of .87 and .95, with 23 and 31 percent higher lamb survival than for ewes of CSL 2.5 (Table 6). Treatment did not effect lamb survival. Lamb survival for ewes giving birth to singles was 10 and 8 percent higher than lambs from ewes giving birth to twins and triplets. Female lambs had 2 percent better survival than male lambs. Lambs born from Polypay sires had 6 and 12 percent higher lamb survival than for lambs from Hampshire and Coopworth sires, respectively ($P\sim.1$).

Individual lamb weaning weights (WWT) adjusted for weaning rank, sex and sire breed were 4 and 6 lbs heavier for lambs from ewes of CSL 3 and 3.5, respectively, than for lambs from ewes of CSL 2.5 ($P\sim.1$; Table 8). Hampshire-sired lambs weighed the most at weaning (65 lbs) compared to Polypay- and Coopworth-sired lambs (60.5 and 58 lbs, respectively; $P<.001$). There was no significant effect of sex of lamb on WWT. There was significant effect of weaning rank on WWT ($P <.001$). Lambs born and weaned as single (S/S) or born as twins but weaned as singles (T/S) were 19 and 6 lbs heavier than lambs born and weaned as twins (T/T).

**b. Ewe productivity:**

Total weight of lamb born (TWB) for ewes of CSL 3 and 3.5 was 2 lbs heavier than for ewes of CSL 2.5, as shown in Table 10. Birth rank had a significant effect on TWB (P<.001). Ewes giving birth to triplets and twin lambs had 9 and 7 lbs higher TWB, respectively, than ewes giving birth to singles (P<.001).

Ewes in poor condition at lambing produced a lower total weight of lamb weaned (TWW) than ewes in good body condition as shown in Table 12 (P<.001). Birth rank had a significant effect on TWW (P<.001) with ewes giving birth to twins averaging 86 lbs, 24 lbs higher than for ewes giving birth to singles. Ram breed had a significant effect on TWW (P<.001) with Polypay mated ewes having highest TWW followed by Hampshire- and Coopworth-mated ewes.

**Trial 1a (OSU Polypay):**

**b. Lamb survival and growth:**

Lamb survival was not effected by treatment or ewe body condition as shown in Table 6. Although none of the effects were significant, lamb survival for ewes giving birth to singles was slightly lower than for ewes giving birth to multiple lambs, female lambs had 3 percent better survival than male lambs, and lambs from Polypay sires had 5 and 7 percent lower lamb survival than lambs from the Hampshire and Coopworth sires, respectively.

Individual lamb weaning weights (WWT) adjusted for weaning rank, sex and sire breed were slightly heavier for lambs from C ewes than for lambs from S ewes of the same CSL (Table 8). Ewe CSL did not effect lamb WWT. Hampshire-sired lambs weighed the most at weaning (74 lbs) compared to Polypay and Coopworth-sired lambs (both 65 lbs, P<.001). There was a significant effect of sex of lamb on WWT (P<.001) with male lambs being 4 lbs heavier than female lambs. The effect of weaning rank on WWT was also significant (P <.001), with lambs born and reared as single (S/S) 5 and 14 lbs heavier than lambs born as multiples and reared as single (T/S) or lambs born as multiple and reared as twins (T/T).

**b. Ewe productivity:**

Pre-lambing supplementation (S) was given only to ewes of 2.5 or lower at mid-gestation. The remainder of the flock was regarded as a control (C). Due to few ewes giving birth to singles, only ewes giving birth to twins or triplets were included in TWB and TWW analyses. Ewe body condition at lambing did not effect TWB (Table 10); however, supplemented ewes of CSL 3 had .8 lb more TWB than C ewes of the same CS. Birth rank had a significant effect on TWB (P<.001); ewes bearing triplets had 2 lbs greater TWB compared to ewes bearing twins. Hampshire-mated ewes had heaviest TWB followed by the Coopworth and Polypay-mated ewes (P<.01).

Total weight of lamb weaned by the S ewes was 112 lbs, 6 lbs lighter than for the C ewes (Table 12, P~.12). There was no significant effect of CSL on TWW; however, the ewes of better CS at mid gestation (C) had TWW of 118 lbs as compared to 112 lbs of TWW by the supplemented ewes (P~.14).

The effect of birth rank on TWW was significant (P<.001); ewes giving birth to twins had TWW of 119 lbs, 9 lbs heavier than ewes giving birth to triplets. The effect of ram breed on TWW was significant with Hampshire-mated ewes having TWW of 130 lbs, 19 and 26 lbs heavier than the Coopworth- and Polypay-mated ewes (P<.001).

**Trial 2 (Farm 1 Coopworth):**

**a. Lamb survival and growth:**

Due to few ewes of CSL < 3.0, only ewes of CSL 3.0 and 3.5 were included in analyses. Since records of ewes for controls were selected by matching the litter size, birth date and weaning rank of S ewes, survival of lambs from C ewes is not relevant. Supplemented ewes of CSL 3.0 had 3 percent lower lamb survival than for CSL 3.5 ewes. There was a significant effect of supplementation on lamb WWT (Results not shown, P<.01). Lambs from S ewes had 4 lbs heavier WWT than lambs from C ewes. Ewe CSL did not affect WWT.

**b. Ewe productivity:**

Control ewes had no birth weight data so it was not possible to estimate supplementation effect on TWB. Among S ewes, CSL did not affect TWB, likewise the effect of CSL on TWW was not significant (results not shown).

**Trial 3 (Farm 2, Crossbred ewes):**

**a. Lamb survival and growth:**

The effect of treatment on lamb survival was not significant (Table 6); however, lambs from S ewes had 3 percent better survival than lambs from C ewes. The effect of CSL on lamb survival was significant (P<.001); survival of lambs from CSL 2.5 ewes was only 56 percent, 21, 26 and 37 percent lower than the ewes of CSL 3, 3.5 and 4, respectively. The effects of birth rank and lamb sex on lamb survival were very small.

Ewe body condition had a significant effect on lamb WWT (P<.001, Table 8) with lambs from dams of poor CSL having lower WWT than lambs from dams of good body condition. Sex of lamb had a significant effect on WWT; female lambs weighed 81 lbs vs 84 lbs for males (P<.05). Weaning rank also had a significant effect on WWT of lambs (P<.001); WWT of lambs weaned as S/S was 89 lbs, compared to WWT of T/S and T/T lambs averaging 82 and 76 lbs, respectively.

**b. Ewe productivity:**

Treatment had no significant effect on TWB as shown in Table 10; however, ewes in poor body condition tended to have lower TWB than ewes of good body condition. The effect of birth rank on TWB was significant (P<.001); mean TWB of ewes giving birth to singles and twins was 11 lb and 19 lbs, respectively.

Treatment did not significantly effect TWW (Table 12), although TWW for S ewes was 4 lbs heavier than for C ewes. Among both S and C ewes as body condition at lambing increased so did TWW (P<.01) going from 61 lbs for ewes of CSL 2.5 to over 116 lbs for CSL 4.0 ewes. Birth rank significantly effected TWW with ewes giving birth to singles having an average of 67 lbs of lamb weaned, compared to 118 lbs for ewes giving birth to twins (P<.001).

**Body Condition Trials:**

**<u>Trial 2a (Farm 1 Coopworth):</u>**

**a. Lamb survival and growth:**

Ewe body condition did not significantly effect lamb survival; however, ewes of poor body condition tended to have better lamb survival than ewes in good body condition (Table 7). Birth rank did not affect lamb survival. Male lambs tended to have better survival than female lambs.

Lamb WWT was effected by dams CSL (Table 9); lambs from the dams of CSL 1.5 were lighter at weaning (P<.05) than lambs from dams of better body condition. Weaning rank had a significant effect on lamb WWT (P<.001) with lambs weaned as singles being 6 lb heavier than lambs weaned as twins. Sex of lamb significantly affected WWT (P<.001) with males and female lambs averaging 59 and 55 lbs, respectively.

**b. Ewe productivity:**

Since birth weight of lambs was not recorded, it was not possible to estimate TWB. Ewe body condition did not have significant effect on TWW (Table 13). Ewes of CSL 3.0 tended to have lowest TWW. Birth rank had a significant effect on TWW (P<.001). Ewes giving birth to single lambs had TWW of 49 lbs, compared to 91 lbs for ewes giving birth to twin lambs.

**Trial 4 (OSU Coopworth):**

**a. Lamb survival and growth:**

Lamb survival was higher for ewes of better CSL (P<.05; Table 7). Lamb survival of single lambs was .77, being 15 percent better than twin lambs (P<.001). Male lambs tended to have better survival than female lambs. Hampshire-sired lambs tended to have better survival than Coopworth-sired lambs (data not shown).

Ewes CSL had a significant affect on lambs WWT (P~.5), although it was not linear (Table 9). Effect of sex of lamb on WWT was significant (P<.05) with male lambs averaging 57 lb and female lambs averaging 53 lb, respectively. Lamb genotype did not affect lamb WWT; however, Hampshire-sired lambs weighed 56 lbs, 4 lbs heavier than Coopworth-sired lambs (not shown). Weaning rank had a significant effect on WWT (P<.001). Lambs weaned as S/S weighed 64 lbs, 11 and 16 lbs heavier than T/S and T/T lambs, respectively.

**b. Ewe productivity:**

Ewe CSL did not significantly effect TWB (Table 11). Birth rank had significant effect on TWB (P<.001). Effect of ram breed on TWB was not significant. The effect of ewe CSL on TWW was not significant (Table 13); however ewes of poor CSL tended to have lower TWW than ewes of better CSL. Ewes bearing single lambs had TWW of 46 lb compared to 64 lbs for ewes bearing twins (P<.001). Hampshire-mated ewes had slightly heavier TWW, 58 lbs vs 51 lbs for Coopworth-mated ewes (results not shown).

**<u>Trial 4a (OSU Coopworth):</u>**

**a. Lamb survival and growth:**

The effect of ewe CSL on lamb survival was not significant, however ewes of CSL 2.0 tended to have poorer lamb survival than ewes of better CS (Table 7). Birth rank had a significant effect on lamb survival; 81 percent of lamb born as twins survived, 7 percent higher than for lambs born as signals. Sex of lamb had no significant effect on lamb survival; however, female lambs had 8 percent lower survival than males. Hampshire-sired lambs tended to have better lamb survival than Coopworth-sired lambs (results not shown).

The effect of ewe CSL on lambs WWT was not significant. Lambs from ewes of good body condition at lambing tended to have heavier WWT compared to lambs from ewes in poor body condition (Table 9). Sex of lamb did not significantly affect lambs WWT; however, male lambs were 2 lb heavier than females. The effect of weaning rank on WWT was significant (P<.05) with lambs weaned as S/S averaged 52 lbs compared to 48 and 46 lbs for T/S and T/T lambs, respectively. Hampshire-sired lambs averaged 52 lbs, 7 lbs heavier than Coopworth-sired lambs (P<.001; not shown).

**b. Ewe productivity:**

Total weight of lamb born was not significantly effected by ewe body condition at lambing (Table 10); however, ewes of better CSL tended to have 1 to 2 lb heavier TWB than ewes of poor CSL. Birth rank had a significant effect on TWB (P<.05). Ewes giving birth to single, twin and triplet lambs had TWB of 11, 17, and 20 lbs, respectively. Ram breed did not have a significant effect on TWB.

Ewe body condition at lambing effected TWW significantly (P<.05, Table 13); ewes of better CSL had better TWW compared to ewes of poor CSL. Ram breed had a significant effect on TWW, with Coopworth- and Hampshire-mated ewes averaging 42 and 52 lbs, respectively (P<.05, not shown). Birth rank had a significant effect on TWW. Ewes bearing single and twin lambs had TWW of 40 and 62 lbs, respectively (P<.005).

**Trial 5 (OSU CPXP):**

**a. Lamb survival and growth:**

Lambs from poor CSL ewes tended to have lower lamb survival than those from good CSL (Table 7). Lamb survival of single born lambs was higher compared to lamb survival for twin born lambs (P<.001). Effect of lamb sex on lamb survival was not significant; however, 83 and 79 percent of males and females survived, respectively. Lambs WWT from ewes of CSL 3.0 tended to be lowest (Table 7). Weaning rank had a significant effect on lamb WWT. Lambs weaned as S/S averaged 67 lbs, 4 and 16 lbs heavier than lambs weaned as T/S and T/T, respectively (P<.001). Male lambs averaged 62 lbs, 2 lb heavier than females.

**b. Ewe productivity:**

Total weight born by ewes of poor CSL tended to be lower than ewes of better CSL (Table 11). Effect of birth rank was significant on TWB, with ewes bearing single lambs having TWB of 13 lbs compared to 19 lbs for ewes bearing twins (P<.001).

Total weight of lamb weaned by ewes of CSL 2.5, 3.0 and 3.5 was 73, 76 and 67 lbs, respectively (Table 13).

Effect of birth rank on TWW was significant. Ewes giving birth to single and twin lambs had mean TWW of 63 and 81 lbs, respectively; ($P<.001$).

**Trial 6 (OSU Hampshire):**

**a. Lamb survival and growth:**

Lamb survival decreased with increase in ewe CSL (Table 7). Lambs born as singles had 9 percent better survival than lambs born as twins. Male lambs had 83 percent survival compared to 76 percent for females.

Lamb WWT adjusted for weaning rank dropped as CSL increased (Table 9). Weaning rank effected WWT significantly. Lambs weaned as S/S, T/S and T/T averaged 70, 63 and 52 lbs, respectively ($P<.001$). Sex of lamb had a significant effect on lamb WWT; female lambs weighed 63 lbs, being 3 lb heavier than male lambs.

**b. Ewe productivity:**

The effect of ewe CSL on TWB was significant; however it was not linear ($P<.06$; Table 11). The effect of birth rank on TWB was significant ($P<.001$); ewes giving birth to single and twin lambs had TWB of 12 and 19 lbs, respectively.

Ewes of CSL 3.0 weaned heavier TWW than ewes of CSL 3.5 or 4.0 (Table 13) although the effect was nonsignificant. Birth rank had a significant effect on TWW, with ewes bearing singles averaging 64 lbs compared to ewes bearing twins averaging 85 lbs ($P<.001$).

**Trial 7 (OSU Crossbred):**

**a. Lamb survival and growth:**

Data for whiteface (WF) and blackface (BF) crossbred ewes were analyzed separately.

There was significant effect of CSL on lamb survival lambs born by WF ewes (P<.05; Table 7). Effect of birth rank on lamb survival of crossbred lambs was not significant. Female lambs tended to have better survival than male lambs. There was no significant effect of ewes CSL on lamb survival of lambs born by BF ewes; however, ewes of better CSL tended to have better lamb survival than ewes of poor CSL. The effect of birth rank on lamb survival of BF crossbred lambs was not significant. Female lambs tended to have better survival than male lambs.

Lamb WWT for lambs from WF ewes was higher for lambs from ewes of better CSL than for lambs for ewes in poor CSL (P<.05; Table 9). Weaning rank had a significant effect on WWT of WF lambs (P<.001). Lambs from WF ewes weaned as S/S, T/S and T/T averaged 68, 60 and 59 lbs, respectively. Sex of lamb had no significant effect on WWT of lambs from WF ewes. Female and male lambs from WF ewes weighed 62 lbs and 63 lbs, respectively. Lamb WWT for lambs from BF ewes tended to be heavier for the lambs from ewes of better CSL than for the lambs of the ewes of CSL 2.5 (Table 9). Weaning rank had a significant effect on lamb WWT of BF lambs (P<.001) with lambs weaned as S/S, T/S and T/T averaging 77, 63 and 65 lbs, respectively. Female averaged 67 lbs, 2 lbs lighter than male lambs.

**b. Ewe productivity:**

The effect of CSL on TWB for whiteface ewes was not significant; however, ewes in better body condition tended to have greater TWB compared to ewes in poor condition (Table 13). The effect of birth rank on TWB was significant, with multiple bearing ewes averaging 20 lbs vs 13 lbs for single bearing ewes (P<.001). The effect of CSL on TWB for blackface ewes was not significant; however, ewes in CSL 4.0 had heaviest TWB followed by the ewes of CSL 3, 3.5 and 2.5, respectively (Table 13). The effect of birth rank on TWB was significant, with multiple bearing ewes averaging 22 lbs compared to 14 lbs for single bearing ewes (P<.001). Ewe body condition at lambing did not significantly effect TWW; however, TWW for ewes of better CSL tended to be heavier than the ewes of poor CSL. This trend was found both in WF and BF crossbred ewes (Table 13). Effect of birth rank was significant both for WF and BF crossbred ewes (P<.001). Whiteface crossbred ewes bearing single and twin lambs weaned 58 lbs and 108 lbs of lamb, respectively. Blackface crossbred ewes giving birth to single and twin lambs weaned 70 lbs and 111 lbs, respectively.

**Relationship Among Body Weight and Body Condition.**

Mean body weight recorded for Polypay (Trial 1a) and Coopworth ewes (Trial 4a) at five times from pre-breeding through weaning are presented in Table 14. Weights were lightest at pre-mating and heaviest at pre-lambing. Weights were consistently heavier for ewes of higher CS, and Polypay ewes were consistently heavier than Coopworth ewes of the same age and CS.

Correlation coefficients calculated between each of the above condition scores and subsequent condition scores are shown in Table 15. Also presented are correlations between CS and body weight at each scoring. The largest coefficients were observed between adjacent CS observations; coefficients declined as the time of observation increased. Condition score and body weight were highly correlated at pre-mating and exhibited the lowest correlation at the pre-lambing observation. Correlations were higher at all times for Coopworth ewes compared to Polypay ewes.

**Table 1: Outline of trials, locations, treatments and ewe genotypes in the two research years.**

| Year | Trial | Location | Treatment[a] | Genotype | No. ewe records | No. records analyzed |
|---|---|---|---|---|---|---|
| 1 | 1 | OSU | Suppl | Polypay(P) | 180 | 145 |
| 1 | 2 | Farm 1 | Suppl | Coopworth(CP) | 158 | 129 |
| 1 | 3 | Farm 2 | Suppl | Crossbred | 200 | 183 |
| 1 | 4 | OSU | CS | Coopworth | 89 | 80 |
| 1 | 5 | OSU | CS | CPXP | 67 | 67 |
| 1 | 6 | OSU | CS | Hampshire | 70 | 50 |
| 1 | 7 | OSU | CS | Crossbred | 194 | 192 |
| 2 | 1a | OSU | Suppl | Polypay | 111 | 108 |
| 2 | 2a | Farm 1 | CS | Coopworth | 349 | 328 |
| 2 | 4a | OSU | CS | Coopworth | 94 | 81 |

[a]Suppl= supplementation trials; CS=body condition trials.

**Table 2: Number of supplemented (S) and control (C) ewes in Supplementation trials at each level of condition score at lambing (CSL) included in analyses.**

| | Trial 1 | | | Trial 1a | | | Trial 2 | | | Trial 3 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CSL | S | C | All | S | C | All | S | C | All | S | C | All |
| 2.5 | 4 | 8 | 12 | 10 | 9 | 19 | - | - | - | 5 | 10 | 15 |
| 3.0 | 25 | 30 | 55 | 34 | 26 | 60 | 34 | - | - | 27 | 33 | 60 |
| 3.5 | 49 | 29 | 78 | 16 | 13 | 29 | 22 | - | - | 49 | 36 | 85 |
| 4.0 | - | - | - | - | - | - | - | - | - | 12 | 11 | 23 |
| Mean | 78 | 67 | 145 | 60 | 48 | 108 | 56 | 73 | 129 | 93 | 90 | 183 |

**Table 3: Number of ewes in Body Condition trials at each level of condition score at lambing (CSL) included in analyses.**

| | Trial 2a | Trial 4 | Trial 4a | Trial 5 | Trial 6 | Trial 7[a] | |
|---|---|---|---|---|---|---|---|
| | | | | | | WF | BF |
| CSL | | | | | | | |
| 1.5 | 62 | - | - | - | - | - - | - |
| 2.0 | 133 | 13 | 28 | - | - | 35 | - |
| 2.5 | 93 | 31 | 34 | 26 | - | 28 | 14 |
| 3.0 | 40 | 28 | 19 | 30 | 10 | 46 | 26 |
| 3.5 | - | - | - | 11 | 32 | 20 | 12 |
| 4.0 | - | - | - | - | 8 | - | 11 |
| Mean | 328 | 80 | 81 | 67 | 50 | 129 | 63 |

**Table 4: Least squares means for litter size at birth by supplemented (S) and control (C) ewes of different body condition at lambing (CSL) in Supplementation trials.**

| Item | Trial 1 | | | Trial 1a | | | Trial 3 | | |
|---|---|---|---|---|---|---|---|---|---|
| | S | C | All | S | C | All | S | C | All |
| CSL | | | | | | | | | |
| 2.5 | 2.77(4) | 2.32(8) | 2.50(12) | 2.49(10) | 2.36(9) | 2.41[b] (19) | 1.20(5) | 1.40(10) | 1.34(15) |
| 3.0 | 2.39(25) | 2.06(30) | 2.22(55) | 2.18(34) | 2.09(26) | 2.13[ab](60) | 1.59(27) | 1.58(33) | 1.58(60) |
| 3.5 | 2.16(49) | 2.14(29) | 2.13(78) | 2.06(16) | 1.97(13) | 1.99[a](29) | 1.71(49) | 1.61(36) | 1.69(85) |
| 4.0 | - | - | - | - | - | - | 1.50(12) | 1.55(11) | 1.52(23) |
| Mean | 2.37(78) | 2.19(67) | - | 2.23(60) | 2.13(48) | - | 1.54(93) | 1.51(90) | - |
| Ram breed[c] | | | | | | | | | |
| H | | | 2.18a(55) | | | 2.14(34) | | | - |
| P | | | 2.53[b](32) | | | 2.16(40) | | | - |
| CP | | | 2.18[a](58) | | | 2.24(34) | | | - |

[a,b] Means within trial which do not share a common superscript are significantly different (P<.05).
[c] H=Hampshire; P=Polypay; CP=Coopworth.

**Table 5: Least squares means for litter size at birth by ewe condition score at lambing (CSL) for different Body Condition trials.**

| | Trial 2a | Trial 4 | Trial 4a | Trial 5 | Trial 6 | Trial 7[a] | |
|---|---|---|---|---|---|---|---|
| | | | | | | WF | BF |
| CSL | | | | | | | |
| 1.5 | 1.39(62) | - | - | - | - | - | - |
| 2.0 | 1.38(133) | 2.08(13) | 2.01(28) | - | - | 1.94(35) | - |
| 2.5 | 1.38(93) | 1.81(31) | 2.00(34) | 1.92(26) | - | 2.96(28) | 1.86(14) |
| 3.0 | 1.38(40) | 1.70(36) | 1.84(19) | 1.87(30) | 1.70(10) | 1.65(46) | 1.81(26) |
| 3.5 | - | - | - | 1.73(11) | 1.71(32) | 1.70(20) | 1.83(12) |
| 4.0 | - | - | - | - | 1.63(8) | - | 1.64(11) |
| Mean | 1.38 | 1.86 | 1.95 | 1.84 | 1.68 | 1.8 | 1.8 |

[a] WF=whiteface crossbred ewes; BF=blackface crossbred ewes.

**Table 5 a: Least squares means for litter size at birth by ewes condition score at breeding (CSB) for Polypay (Trial 1a) and Coopworth (Trial 4a) ewes.**

| | Trial 1a | Trial 4a |
|---|---|---|
| CSB | | |
| 2.0 | 2.08(13) | 1.63 (8) |
| 2.5 | 2.04(26) | 1.74(23) |
| 3.0 | 2.18(34) | 1.79(34) |
| 3.5 | 2.28(29) | 1.93(14) |
| Mean | 2.15 | 1.78 |

**Table 6: Least squares means for survival of lambs for supplemented(S) and control(C) ewes by ewes condition score at lambing (CSL), lamb birth rank, lamb sex and ram breed for Supplementation trials.**

| | Trial 1 | | | Trial 1a | | | Trial 2 | Trial 3 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Item | S | C | All | S | C | All | S | S | C | All |
| CSL | | | | | | | | | | |
| 2.5 | .72(7) | .61(16) | .64[a](23) | .97(21) | .90(16) | .95(37) | - | .50(4) | .57(14) | .56[a](18) |
| 3.0 | .80(46) | .92(54) | .87[b](100) | .89(68) | .94(47) | .91(115) | .84(43) | .82(38) | .74(50) | .77[a](88) |
| 3.5 | .98(91) | .90(56) | .95[b](147) | .96(31) | .90(22) | .94(53) | .87(23) | .82(76) | .83(59) | .82[b](135) |
| 4.0 | - | - | - | - | - | - | - | 1.00(18) | .85(13) | .93[b](31) |
| Mean | .82 | .82 | - | .93 | .93 | - | - | .79 | .76 | - |
| Birth Rank | | | | | | | | | | |
| Single | | | .88(21) | | | .90(9) | - | | | .77(74) |
| Twin | | | .78(167) | | | .96(138) | - | | | .77(198) |
| Triplet | | | .80(82) | | | .93(58) | - | | | - |
| Sex | | | | | | | | | | |
| Male | | | .81(123) | | | .92(93) | - | | | .78(150) |
| Female | | | .83(147) | | | .95(112) | - | | | .77(122) |
| Ram Breed[d] | | | | | | | | | | |
| H | | | .82(99) | | | .94(66) | - | | | - |
| P | | | .88(62) | | | .89(74) | - | | | - |
| CP | | | .76(109) | | | .96(65) | - | | | - |

[a,b,c] Means within trial which do not share a common superscript are significantly different ($P<.05$).
[d] H=Hampshire; P=Polypay; CP=Coopworth.

**Table 7: Least square means for survival of lambs by ewes condition score at lambing (CSL), lamb birth rank (BR) and lamb sex for Body Condition trials.**

| Item | Trial 2a | Trial 4 | Trial 4a | Trial 5 | Trial 6 | Trial 7[c] | |
|---|---|---|---|---|---|---|---|
| | | | | | | WF | BF |
| CSL | | | | | | | |
| 1.5 | .91(84) | - | - | - | - | - | - |
| 2.0 | .88(181) | .53[a](22) | .62(49) | - | - | .91(55) | - |
| 2.5 | .83(125) | .75[ab](53) | .72(58) | .76(45) | - | .73(42) | .82(23) |
| 3.0 | .79(53) | .81[b](62) | .70(31) | .85(53) | .87(17) | .85(70) | .91(41) |
| 3.5 | - | - | - | .82(18) | .79(51) | .75(28) | .80(21) |
| 4.0 | - | - | - | - | .73(13) | - | .98(19) |
| Birth Rank[d] | | | | | | | |
| S | .85(201) | .77[b](23) | .74(18) | .89[b](17) | .84(19) | .81(38) | .93[b](16) |
| T | .85(242) | .62[a](114) | .81(110) | .73[a](99) | .75(62) | .81(157) | .83[a](88) |
| Sex[e] | | | | | | | |
| M | .87(217) | .73(78) | .72(54) | .83(44) | .83(36) | .78(98) | .86(59) |
| F | .83(226) | .66(59) | .64(84) | .79(72) | .76(45) | .83(97) | .90(45) |

[a,b] Means within trial which do not share a common superscript are significantly different (P<.05).
[c] WF= whiteface crossbred ewes; BF= blackface crossbred ewes.
[d] S=single; T=twin lambs.
[e] M=male; F=female lambs.

Table 8: Least squares means for individual lamb weaning weight (WWT, lbs) by supplemented (S) and control (C) ewes of different body condition at lambing (CSL) in Supplementation trials.

| | Trial 1 | | | Trial 1a | | | Trial 3 | | |
|---|---|---|---|---|---|---|---|---|---|
| Item | S | C | All | S | C | All | S | C | All |
| CSL | | | | | | | | | |
| 2.5 | 56.9(5) | 58.6(9) | 57.9(14) | 66.1(21) | 71.1(15) | 68.4(36) | 74.9(2) | 72.8 (8) | 73.0$^{a}$(10) |
| 3.0 | 63.1(36) | 61.1(48) | 61.9(84) | 66.2(62) | 68.1(45) | 67.2(107) | 85.8(31) | 84.2(37) | 84.9$^{ab}$(68) |
| 3.5 | 63.2(85) | 64.6(50) | 63.7(135) | 68.2(30) | 69.1(20) | 68.8(50) | 84.9(61) | 84.8(49) | 84.9$^{ab}$(110) |
| 4.0 | - | - | - | - | - | - | 83.9(18) | 94.0(11) | 88.0$^{b}$(29) |
| Mean | 61.1(126) | 61.3(107) | | 67.0((113) | 69.3(80) | - | 82.3(112) | 83.2(105) | - |
| Weaning Rank[d] | | | | | | | | | |
| S | - | - | 71.7$^{c}$(20) | - | - | 74.3$^{c}$(8) | - | - | 89.5$^{c}$(58) |
| T/S | - | - | 59.4$^{b}$(37) | - | - | 69.6$^{b}$(9) | - | - | 82.4$^{b}$(31) |
| T/T | - | - | 52.5$^{a}$(176) | - | - | 60.5$^{a}$(176) | - | - | 76.2$^{a}$(128) |
| Sex[e] | | | | | | | | | |
| M | - | - | 61.4(105) | - | - | 70.2$^{b}$(86) | - | - | 84.2$^{b}$(120) |
| F | - | - | 61.0(128) | - | - | 66.1$^{a}$(107) | - | - | 81.3$^{a}$ (97) |
| Ram Breed[f] | | | | | | | | | |
| H | - | - | 64.9$^{b}$(84) | - | - | 73.9$^{b}$(63) | - | - | - |
| P | - | - | 60.5$^{b}$(59) | - | - | 65.1$^{a}$(67) | - | - | - |
| CP | - | - | 58.3$^{a}$(90) | - | - | 65.4$^{b}$(63) | - | - | - |

[a,b,c] Means within trial which do not share a common superscript are significantly different (P<.05).
[d] M= male; F= female.
[e] S=born and weaned as single; T/S= born multiple, weaned as single; T/T= multiple born and weaned as twin.
[f] H=Hampshire; P=Polypay; CP=Coopworth.

**Table 9: Least squares means for individual lamb weaning weight (WWT, lbs) by ewes body condition score at lambing (CSL), lamb sex and weaning rank for Body Condition trials.**

| Item | Trial 2a | Trial 4 | Trial 4a | Trial 5 | Trial 6 | Trial 7$^{c}$ WF | Trial 7$^{c}$ BF |
|---|---|---|---|---|---|---|---|
| CSL | | | | | | | |
| 1.5 | 54.3(76) | - | - | - | - | - | - |
| 2.0 | 57.7(159) | 55.5$^{b}$(11) | 46.7a(30) | - | - | 58.7(56)$^{a}$ | - |
| 2.5 | 58.3(105) | 53.2$^{a}$(37) | 49.3$^{ab}$(45) | 60.6$^{a}$(32) | - | 63.1(33)$^{ab}$ | 64.9(20) |
| 3.0 | 57.3(42) | 55.1$^{ab}$(47) | 50.0$^{b}$(24) | 59.1a(41) | 65.2(15) | 64.5(61)$^{b}$ | 68.0(40) |
| 3.5 | - | - | - | 62.3$^{b}$(14) | 62.3(40) | 63.5(21)$^{b}$ | 71.8(16) |
| 4.0 | - | - | - | - | 56.7(9) | - | 68.0(18) |
| Sex$^{d}$ | | | | | | | |
| M | 58.7(183) | 56.6(55)$^{b}$ | 49.5(58) | 61.6(32) | 59.9$^{a}$(29) | 63.1(86) | 69.1(52)$^{b}$ |
| F | 55.3(198) | 52.6(40)$^{a}$ | 47.8(58) | 59.9(55) | 62.9$^{b}$(35) | 61.8(85) | 67.3(42)$^{a}$ |
| Weaning rank$^{e}$ | | | | | | | |
| S | 58.4$^{b}$(174) | 63.7$^{b}$(19) | 51.8$^{b}$(13) | 67.2$^{b}$(15) | 69.7$^{b}$(16) | 68.3(65)$^{b}$ | 76.9(15)$^{b}$ |
| T/S | 59.0$^{b}$(37) | 53.0$^{a}$(15) | 48.0$^{a}$(16) | 62.9$^{b}$(14) | 62.6$^{b}$(12) | 60.0(15)$^{a}$ | 62.9 (7)$^{a}$ |
| T/T | 53.5$^{a}$(170) | 47.1$^{a}$(61) | 46.1$^{a}$(71) | 51.4$^{a}$(58) | 52.3$^{a}$(36) | 59.0(126)$^{a}$ | 64.7(74)$^{a}$ |

$^{a,b}$ Means within trial which do not share a common superscript are significantly different (P<.05).

$^{c}$ WF= whiteface crossbred ewes; BF= blackface crossbred ewes.

$^{d}$ M= male; F= female.

$^{e}$ S=born and weaned as single; T/S= born multiple, weaned as single; T/T= multiple born and weaned twin.

Table 10: **Least squares mean for total weight of lamb born (TWB, lbs) by supplemented (S) and control (C) ewes of different body condition at lambing (CSL), birth rank and ram breed in Supplementation trials.**

| | Trial 1 | | | Trial 1a | | | Trial 3 | | |
|---|---|---|---|---|---|---|---|---|---|
| Item | S | C | All | S | C | All | S | C | All |
| CSL | | | | | | | | | |
| 2.5 | 13.7(4) | 13.9(8) | 14.0$^{a}$(12) | 20.7(10) | 21.7(9) | 20.9(19) | 15.4(4) | 13.8(10) | 14.2(14) |
| 3.0 | 16.4(25) | 16.6(30) | 16.5$^{b}$(55) | 21.5(33) | 20.7(21) | 21.2(54) | 15.4(29) | 15.1(29) | 15.2(54) |
| 3.5 | 16.9(49) | 15.6(29) | 16.5$^{b}$(78) | 20.4(14) | 21.0(11) | 20.6(25) | 14.8(46) | 14.9(35) | 14.9(81) |
| 4.0 | - | - | - | - | - | - | 15.7(12) | 16.5(11) | - |
| Mean | 16.0(78) | 15.3(67) | - | 21.0(57) | 20.8(41) | - | 15.1(87) | 15.1(85) | - |
| Birth Rank | | | | | | | | | |
| Single | | | 10.3$^{a}$(21) | | | - | | | 11.3$^{a}$(73) |
| Twin | | | 17.1$^{b}$(84) | | | 19.8(73) | | | 18.9$^{b}$(101) |
| Triplet | | | 19.6$^{c}$(40) | | | 22.0(25) | | | - |
| Ram Breed[d] | | | | | | | | | |
| H | - | - | 16.7$^{b}$(55) | - | - | 22.0$^{a}$(32) | - | - | - |
| P | - | - | 15.7$^{ab}$(32) | - | - | 19.9$^{b}$(35) | - | - | - |
| CP | - | - | 14.5$^{a}$(58) | - | - | 20.7$^{ab}$(31) | - | - | - |

[a,b,c] Means within trial which do not share a common superscript are significantly different (P<.05).
[d]H=Hampshire; P=Polypay; CP=Coopworth.

**Table 11: Least squares means for total weight of Lamb born (TWB, lbs) by ewes body condition at lambing (CSL) and birth rank for Body Condition trials.**

| Item | Trial 4 | Trial 4a | Trial 5 | Trial 6 | Trial 7[c] | |
|---|---|---|---|---|---|---|
| | | | | | WF | BF |
| CSL | | | | | | |
| 2.0 | 14.4(13) | 15.1(28) | - | - | 15.8(31) | - |
| 2.5 | 13.3(31) | 16.9(34) | 15.7(26) | - | 16.0(24) | 16.6(13) |
| 3.0 | 14.6(36) | 15.9(19) | 15.5(30) | 15.1(10) | 16.9(44) | 18.9(26) |
| 3.5 | - | - | 17.1(11) | 17.0(32) | 16.6(18) | 17.6(12) |
| 4.0 | - | - | 14.7 (8) | 19.7(10) | - | 19.9(11) |
| Birth Rank | | | | | | |
| S | 10.4$^{a}$(23) | 11.0$^{a}$(18) | 12.9$^{a}$(17) | 12.1$^{a}$(19) | 14.1$^{a}$(14) | 13.1$^{a}$(32) |
| T | 17.8$^{b}$(51) | 16.8$^{b}$(49) | 19.3$^{b}$(50) | 19.2$^{b}$(31) | 21.8$^{b}$(38) | 20.3$^{b}$(69) |
| Tr | - | 20.0$^{b}$(14) | - | - | - | - |

[a,b] Means within trial which do not share a common superscript are significantly different (P<.05).
[c]WF= white face crossbred ewes and BF= blackface crossbred ewes.
[d] S=single; T=twin lambs; Tr=triplets.

**Table 12: Least squares means for total weight of lamb weaned (TWW, lbs) by supplemented (S) and control (C) ewes of different body condition at lambing (CSL), birth rank and ram breed in Supplementation trials.**

| | Trial 1 | | | Trial 1a | | | Trial 3 | | |
|---|---|---|---|---|---|---|---|---|---|
| Item | S | C | All | S | C | All | S | C | All |
| CSL | | | | | | | | | |
| 2.5 | 60.7(4) | 43.4(8) | 49.2$^{a}$(12) | 114.3(10) | 115.4(9) | 115.2(19) | 48.4(5) | 66.0(10) | 60.8$^{a}$(15) |
| 3.0 | 75.5(25) | 83.5(30) | 80.0$^{b}$(55) | 108.2(33) | 118.6(20) | 112.9(53) | 99.0(27) | 88.1(32) | 93.3$^{b}$(59) |
| 3.5 | 91.2(49) | 90.6(29) | 90.1$^{c}$(78) | 115.6(14) | 117.0(11) | 116.8(25) | 100.6(48) | 100.8(36) | 100.4$^{b}$(83) |
| 4.0 | - | - | - | - | - | - | 121.2(12) | 110.1(11) | 115.8$^{b}$(23) |
| Mean | 72.8(78) | 74.3(67) | - | 111.9(57) | 118.1(40) | - | 94.4(92) | 90.7(89) | - |
| Birth Rank | | | | | | | | | |
| Single | | | 61.7$^{a}$(21) | | | - | | | 67.3$^{a}$(76) |
| Twin | | | 85.5$^{b}$(124) | | | 119.4(72) | | | 117.8$^{b}$(105) |
| Triplet | | | - | | | 110.6(25) | | | - |
| Ram Breed[b] | | | | | | | | | |
| H | | | 76.3$^{b}$(55) | | | 130.0$^{b}$(31) | | | - |
| P | | | 82.1$^{b}$(32) | | | 103.9$^{a}$(35) | | | - |
| CP | | | 62.3$^{a}$(58) | | | 111.1$^{a}$(31) | | | - |

[a] Means within trial which do not share a common superscript are significantly different (P<.05).
[b]H=Hampshire; P=Polypay; CP=Coopworth.

**Table 13: Least squares mean for total weight of lamb weaned (TWW, lbs) by ewes body condition at lambing (CSL) and birth rank for Body Condition trials.**

| Item | Trial 2a | Trial 4 | Trial 4a | Trial 5 | Trial 6 | Trial 7[c] | |
|---|---|---|---|---|---|---|---|
| | | | | | | WF | BF |
| CSL | | | | | | | |
| 1.5 | 69.8(62) | - | - | - | - | - | - |
| 2.0 | 73.0(133) | 44.7(10) | 35.2$^{a}$(28) | - | - | 77.9(34) | - |
| 2.5 | 70.4(159) | 52.2(29) | 56.9$^{b}$(34) | 72.5(29) | - | 76.0(22) | 76.7(13) |
| 3.0 | 65.8(43) | 66.7(35) | 55.7$^{b}$(19) | 75.9(25) | 83.9(10) | 78.8(45) | 94.0(24) |
| 3.5 | - | - | - | 67.3(11) | 67.6(32) | 84.0(15) | 86.5(11) |
| 4.0 | - | - | - | - | 71.2 (8) | - | 105.3(11) |
| Birth Rank[d] | | | | | | | |
| S | 49.0$^{a}$(125) | 45.6$^{a}$(23) | 39.9$^{a}$(18) | 63.1$^{a}$(17) | 63.6$^{a}$(19) | 58.4$^{a}$(35) | 70.0$^{a}$(16) |
| T | 90.5$^{b}$(203) | 63.5$^{b}$(51) | 61.6$^{b}$(63) | 80.7$^{b}$(48) | 84.8$^{b}$(31) | 107.7$^{b}$(72) | 111.2$^{b}$(43) |
| Tr | - | - | - | - | - | - | - |

[c]WF= whiteface crossbred ewes; BF= blackface crossbred ewes.
[a,b] Means within trial which do not share a common superscript are significantly different (P<.05).
[d] S=Single of single; T/S= Twin single; T/T=Twin twin

**Table 14: Least squares means for body weight of Polypay (Trial 1a) and Coopworth (Trial 4a) ewes at various condition scores (CS) and ages at five times during the production year.**

| | Body weight | | | | |
|---|---|---|---|---|---|
| | Pre-breeding | Post-mating | Mid-gestation | Pre-lambing | Weaning |
| Polypay | | | | | |
| CS | | | | | |
| 2.0 | 123.5[a](13) | - | 135.8[a](12) | - | - |
| 2.5 | 131.9[b](26) | 139.3[a](13) | 140.9[a](47) | 171.9(17) | 149.6[a](20) |
| 3.0 | 136.5[c](34) | 145.1[b](42) | 147.4[ab](35) | 170.4(57) | 153.7[a](57) |
| 3.5 | 143.8[d](29) | 152.7[c](42) | 151.8[b](12) | 170.4(28) | 161.0[b](20) |
| Age | | | | | |
| 3 | 128.6[a](25) | 139.0[a](23) | 138.2[a](24) | 163.2[a](23) | 147.8[a](25) |
| 4 | 139.3[b](77) | 152.4[b](74) | 149.8[b](82) | 178.6[b](79) | 161.7[b](72) |
| Coopworth | | | | | |
| CS | | | | | |
| 1.5 | - | - | - | 105.7[a](8) | - |
| 2.0 | 113.4[a](10) | - | 116.9[a](19) | 130.5[b](18) | 120.0[a](6) |
| 2.5 | 117.3[a](24) | 123.9[a](13) | 128.8[a](47) | 145.0[b](34) | 132.2[b](14) |
| 3.0 | 130.2[b](24) | 135.9[b](51) | 140.0[b](13) | 152.5[b](17) | 144.6[b](22) |
| 3.5 | 139.7[c](16) | 142.8[b](19) | - | - | 151.9[b](10) |
| Age | | | | | |
| 2 | 119.3[a](34) | 124.8[a](31) | 116.6[a](32) | 119.1[a](30) | 127.7(23) |
| 3 | 123.9[b](10) | 135.7[b](9) | 131.8[b](10) | 138.5[b](9) | 137.4(4) |
| 4 | 132.3[b](45) | 142.1[b](43) | 137.3[b](37) | 142.6[b](38) | 146.3(25) |

[a,b,c,d] Columns which do not share a common superscript are significantly different ($P<.05$).

**Table 15: Correlation coefficients [a] (± SE) of individual ewe condition scores (CS) with subsequent scores and body weight at time of scoring for Polypay (Trial 1a) and Coopworth (Trial 4a) ewes.**

| | Condition Score[b] | | | |
|---|---|---|---|---|
| | CSP | CSM | CSL | Body weight |
| POLYPAY | | | | |
| CSB | .65± .12 | .43± .09 | .20± .09 | .59± .08 |
| CSP | - | .45± .09 | .13± .10 | .46± .09 |
| CSM | - | - | .11± .10 | .37± .09 |
| CSL | - | - | - | -0.10±.10 |
| COOPWORTH | | | | |
| CSB | .67± .09 | .68± .10 | .52± .08 | .67± .09 |
| CSP | - | .76± .08 | .52± .08 | .47± .11 |
| CSM | - | - | .56± .08 | .49± .11 |
| CSL | - | - | - | .39± .13 |

[a] Correlations= .20 and greater are significant (P<.05)

[b] CSb= Condition score at pre-breeding; CSP= Condition score at post mating; CSM= Condition score at mid gestation; CSL; Condition score at lambing.

# CHAPTER 4

# DISCUSSION

Ewe productivity is made up of several components and thus can be defined in many ways (eg. number of lambs born per ewe mated, number of lambs weaned per ewe lambed, weight of lamb weaned per ewe lambing). In this study, ewe productivity (total weight of lamb weaned per ewe lambing) was measured on an annual basis. Several trials involving various ewe breeds were conducted to estimate the effect of pre-lambing ewe body condition on ewe productivity. Since ewe body condition is confounded with nutrition, two sets of trials were conducted to look separately at the effects of ewe body condition and pre-lambing supplementation.

In general, supplementation pre-lambing increased ewe body condition. In most of the trials ewes of better body condition at lambing (CSL) had heavier total weight of lamb weaned (TWW) compared to ewes of poor body condition. These findings are consistent with the study of Nawaz et al. (1992b) and Nawaz and Meyer (1992), who reported heavier TWW by Polypay, Coopworth and Suffolk ewes of heavier live weight at lambing. The effect of CSL on total weight of lamb weaned was due to combined CSL effects on lamb survival and individual lamb weaning weights.

The higher lamb survival by ewes of better body condition observed in most of the trials is in agreement with the reports of Jefferies, (1957) and Jordan and Hanke (1991) who reported higher lamb survival by ewes of higher CSL. Ewes in their study had mean CSL of 3.5. In Year 1, Polypay-sired lambs had better lamb survival than Hampshire-sired and Coopworth-sired lambs; however, in Year 2, Coopworth-sired lambs had better lamb survival than Hampshire-sired and Polypay-sired lambs. This may be due to a breed effect, year effect or heterosis. Nawaz and Meyer (1992) and Nawaz et al. (1992b) reported higher lamb survival of Suffolk-sired lambs compared to Polypay- and Coopworth-sired lambs born to similar ewes in the same flock. Increased survivability of crossbred lambs due to individual heterosis is well documented in the literature (Dickerson et al., 1975; Dickerson and Glimp, 1975; Lewis and Burfening, 1988; Nawaz et al., 1992b). Litter size had substantial effect on lamb survival in most trials as would be expected. Lambs born as singles have better survival than those born as multiples. This has been reported previously by several researchers (Sidwell and Miller, 1971; Smith, 1977; Mellor, 1990; Nawaz and Meyer, 1992); however, in Trials 2, 2a, 3, 4a and 7, litter size had no effect on lamb survival. This may be either due to breed effect or low mean ewe body condition.

A trend of better survival of female lambs compared with male lambs was found in most trials which is in agreement with the studies of Hight and Jury (1970), Meyer et al. (1977), Smith (1977), and Oltenacu and Boylan (1981a, 1981b). However, in Trial 2a, 3, 4, 4a, 5 and 6 involving Coopworth, Hampshire and crossbred ewes, male lambs had higher survival than female lambs. This may have been due to a breed effect since Nawaz and Meyer (1992) also reported better survival of male lambs than female lambs born to Coopworth ewes. Lambs born to ewes of better CSL had heavier individual lamb weaning weights (WWT) in most of the trials. Heavier individual weaning weights of lambs from ewes of better CSL or heavier live weight have been previously reported by Berggren-Thomas (1984), Beeston (1984), Holst et al. (1986), Nawaz and Meyer (1992), and Nawaz et al. (1992b). In most of our trials birth and rearing rank affected lamb WWT. Lambs born and weaned as singles or born as twins but weaned as singles (S/S, T/S) generally had higher WWT than lambs born and weaned as twins (T/T). These findings are consistent with earlier studies by Cochran et al. (1984), Berggren-Thomas (1984), Lewis and Burfening (1988), Nawaz and Meyer (1992) and Nawaz et al. (1992b). Among lambs born to Polypay ewes, Hampshire-sired lamb were heavier at weaning than Polypay- or Coopworth-sired lambs. This may be due to either a breed effect or heterosis. Nawaz and Meyer (1992) reported heavier WWT of Suffolk-sired lambs than Polypay- and Coopworth-sired lambs born in the same flock.

Supplementation by feeding one pound whole corn daily 4 to 6 weeks pre-lambing improved body condition, particularly for thin ewes. Supplementation did not affect litter size, as litter size has been determined well before the time ewes were supplemented. A trend of higher litter size for ewes of better condition at breeding was found for Polypay and Coopworth ewes in Trials 1a and 4a. Coop (1966a,b) and Bradford (1972a) have also reported an association of higher litter size with better condition ewes in their studies.

Supplementation had no significant effect on TWB, lamb survival, lamb WWT or TWW; however, supplementation mediated its effect through improving pre-lambing body condition. Supplemented ewes tended to have greater total weight of lamb born (TWB). The heavier birth weights suggest that the extra energy received during supplementation was partially converted to fetal growth. This is consistent with earlier studies by Rattray et al. (1974) and Mellor and Murray (1982). Through its effect on CSL, supplementation also helped improve lamb survival. Higher lamb survival for ewes of better body condition has been previously reported by Johnson et al. (1982).

Heavier weaning weights (WWT) of lambs from ewes of better condition indicate that increased ewe body reserves resulting from late gestation supplementation may have resulted in higher milk yield. Sidwell et al. (1962) also reported heavier weaning weights for lambs born to ewes which were subjected to late gestation supplementation.

Although supplementation improved ewe body condition and generally resulted in higher TWB, better lamb survival and heavier individual lamb weaning weight, performance of supplemented thin ewes was not as good as ewes already in good condition prior to supplementation. As shown in Trial 1a, control ewes which were at CS 3.0 from mid-gestation through pre-lambing had better lamb survival, high TWB, and heavier lamb WWT than previously thin ewes which were brought up to body condition 3.0 at time of lambing by pre-lambing supplementation.

Our study results clearly indicate higher total weight of lamb weaned by ewes of better condition at lambing. If good feed is available in abundance, maximal production will be achieved by maintaining ewes in good body condition at all times. In more typical production systems where feed availability is limiting during certain times of the year, ewes should be flushed at breeding and pre-lambing supplementation should be supplied to ewes in poor condition. In such production systems pre-lambing supplementation for 4 to 6 weeks will increase TWW due to both better survival and heavier individual lamb weaning weights. Although TWW of supplemented ewes was not equivalent to TWW of ewes already in good condition, TWW would have been even lower without supplementation.

The differences observed among trials in mean CSL and effects of CSL on TWW may be explained by differences in body fat storage pattern among breeds. Compared to blackface breeds, whiteface breeds tend to store a greater proportion of their body fat as perirenal fat vs subcutaneous fat (Russel et al., 1968).

Serial weights of ewes through the year indicated that ewes were heaviest at lambing, probably due to fetal weight. Berggren-Thomas (1984) also reported heavier body weights of ewes at lambing compared to weights at other key periods of the production cycle.

Correlation coefficients between condition score and body weight were lower during gestation than at previous observation, suggesting that ewes utilized their body reserves to support their fetuses at the expense of their own body condition. Similar results have been reported previously (Berggren-Thomas, 1984; Atkins, 1986).

The approximate cost of pre-lambing supplementation was $.30 per extra pound of lamb weaned. At the typical market price of $.60/ pound, this should prove to be a strong incentive for producers to supplement poor condition ewes pre-lambing.

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