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Lauren N. Wood, Student

Dr. Donald G. Ely, Major Professor

Dr. David Harmon, Director of Graduate Studies

POST WEANING SUPPLEMENTATION OF APRIL-BORN POLYPAY AND WHITE DORPER LAMBS GRAZING ALFALFA/ORCHARDGRASS PASTURE

THESIS

A thesis submitted in partial fulfillment of the
requirements for the degree of Master of Science in the
Department of Animal and Food Sciences
at the University of Kentucky
By

Lauren Nicole Wood

Lexington, Kentucky

Director: Dr. Donald G. Ely, Professor of Animal Science

Lexington, Kentucky

2015

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ABSTRACT OF THESIS

POST WEANING SUPPLEMENTATION OF APRIL-BORN POLYPAY AND WHITE DORPER LAMBS GRAZING ALFALFA/ORCHARDGRASS PASTURE

The effect of post-weaning supplementation of April-born Polypay and White Dorper lambs grazing alfalfa/orchardgrass pasture during two grazing seasons from June to September was studied. One hundred seventy Polypay and 133 White Dorper lambs were randomly allotted to supplemented (2% BW daily) and unsupplemented groups. It was discovered that Polypay lambs weighed more than White Dorpers at wearning, when the grazing season began, and at the end of the 80 (Year 1) and 85 (Year 2) grazing season ($P < 0.01$). Polypay lambs gained faster ($P <0.01$) than White Dorpers. Supplemented lambs gained faster ($P < 0.01$) than unsupplemented and Polypays had a greater response to supplementation ($P < 0.01$) than White Dorpers. Polypays had higher ($P < 0.01$) fecal egg counts, an indicator of *Haemonchus contortus* infestation. Supplementation did not have any consistent effect on reducing *Haemonchus contortus* infestation. Differences in forage characteristics of Polypay and White Dorper lambs did appear. Differences in alfalfa and orchardgrass dry matter, neutral detergent fiber, acid detergent fiber, and crude protein availability were measured by subtracting enter from exit availabilities. The largest decrease of alfalfa components from exit to enter was found with unsupplemented Polypays. No consistent effect was found for orchardgrass components.

Lauren Wood
Student's Signature
November 24, 2015
Date

POST-WEANING SUPPLEMENTATION OF APRIL-BORN POLYPAY AND WHITE DORPER LAMBS GRAZING ALFALFA/ORCHARDGRASS PASTURE

By

Lauren Nicole Wood

Dr. Donald Ely
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November 24, 2015
Date

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Table of Contents

List of Tables

List of Tables continued

List of Appendix Tables

List of Figures

Chapter I

Introduction

Diets fed to sheep around the world contain 85 to 90% roughage (forage), which is more than any other class of livestock (Ely, 1995). With the primary component of sheep diets being roughage, it should be high enough quality to meet their nutritional needs throughout an annual production year. Grazing livestock can consume a variety of forages from legumes (alfalfa, white and red clover, trefoil), grasses (bluegrass, orchardgrass, tall fescue), while some pastures contain a mixture of both grasses and legumes. Legumes are characterized by high protein and high lignin contents, but low cell wall content when compared with grasses. The relatively high cell wall and low lignin concentration in grasses leads to lower voluntary intake relative to digestibility. Alfalfa (*Medicago sativa L.)*, known as the "Queen of the Forages"(Barnes and Shaefer, 1995), is the most important legume produced in the United States. It is grown over a wide range of soil and climatic conditions. It has the highest yield potential and feeding value of all perennial forage legumes. At harvest, the first flower stage of maturity, more than half of the forage consists of leaves and these contain more protein, total digestible nutrients, and vitamins than stems (Kalu and Fick, 1983; Marten et al., 1988). With proper grazing management, alfalfa's high yield potential can be converted to high levels of animal production per hectare. Orchardgrass (*Dactylis glomerata L.*) is a versatile grass and will provide excellent forage for most classes of livestock, especially in the "leafy" stage. However, quality decreases as the plant matures. In order to obtain high animal performance it must be rotationally grazed. Orchardgrass has greater persistence and productivity when rotationally grazed during the first growth of spring.

In addition to type of pasture lambs graze, some other factors that could affect growth and weight gain. There are many different breeds of sheep in the United States but the two used in this study were the Polypay and White Dorper. The Polypay is a prolific wool sheep with favorable growth and carcass characteristics, while the White Dorper is a meat type hair sheep that is noted for its growth and carcass characteristics as well as its mothering ability.

Although the livestock industry as seen a push for grass-fed meat, the length of time from birth to market in lambs is short. So, many sheep producers supplement their grazing lambs with concentrate in order for them to reach market weight in the six short months after weaning (at 60 d of age). Internal parasite infestation is the most limiting factor in sheep production, so monitoring the stomach worm (*Haemonchus contortus*) is pivotal for efficient sheep production. So, this study aimed to answer three questions: 1) to what extent does suppplmentation affect forage intake; 2) to what extent does supplementation and/or breed affect weight gain; and 3) does intestinal parasite infestation vary significantly based on supplementation and/or breed.

Chapter II

Literature Review

Alfalfa

Alfalfa originated in Iran and is grown in every state in the United States (Ball et al., 2002). It is drought tolerant and can survive extreme temperatures of cold and hot. The advantage to grazing alfalfa extends beyond its digestible nutrient concentration. It has the potential for increased DM intake by the consuming animal and faster rate of digestion than other legumes (Marten et al., 1988). It has the ability to fixate nitrogen, which allows the plant to convert atmospheric N into plant amino acids and ultimately plant protein. Alfalfa DM contains a high mineral concentration (especially calcium) along with multiple vitamin precursors (especially carotene). These characteristics make this legume a desirable dietary component of sheep and other ruminant diets for all functions within a production year (Zhu et al., 1996). Any variability in voluntary intake and/or digestibility of alfalfa grazed by ruminants, and ultimate animal productivity, is associated with the variation in total cell wall concentration (Marten et al., 1988).

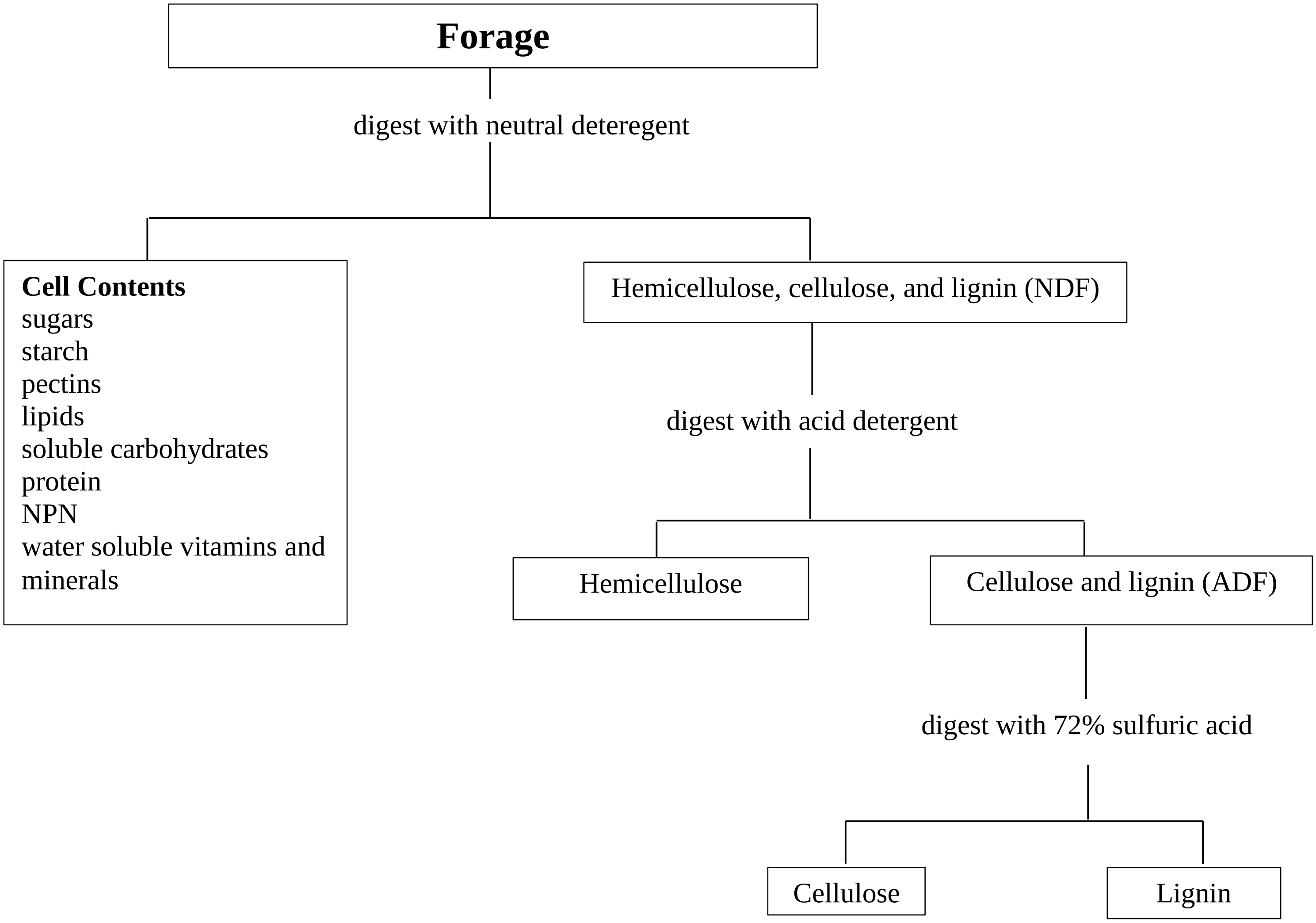
Orchardgrass

Orchardgrass is one of the most productive bunch type, tall growing, and cool season perennial grasses used for hay and pasture in the northern and eastern United States (Lacefield et al., 2003). The bunch type growth characteristic and shade tolerance combine to make it well adapted to compete with tall growing legumes, such as alfalfa (Christie and McElroy, 1995). It regrows quickly, making it well suited for combining with frequently harvested alfalfa. Although regrowth, which is mostly leaves, is high quality (Henning and Risner, 1993), temperatures above 27 to 29° C reduced regrowth and tillering, meaning summer productivity is less than spring (Lacefield et al., 2003). Orchardgrass produces heavy growth during April and May (Christie and McElroy, 1995). Therefore, combining orchardgrass with alfalfa has the potential to produce a productive pasture from spring (orchardgrass) through summer (alfalfa) and into the fall (orchardgrass and alfalfa). This growth can be used for pasture, hay, greenchop, or silage. Grazing it heavily early in the season promotes high yields of high quality forage. It recovers well after grazing or cutting and produces relatively high quality second and third harvest growth (Henning and Risner, 1993). Rotational grazing with heavy stocking rates produces greater animal performance then continuous grazing because selective grazing is reduced. If orchardgrass stands are continually grazed below 10.2 cm of growth during hot weather, the stand can be weakened and could even be depleted (Lacefield et al., 2003). On the other hand, harvesting above this height helps maintain strong root reserves, leading to fast regrowth and greater stand persistence. Alfalfa/orchardgrass mixtures should be harvested when alfalfa is at early bloom and should be managed to favor the legume in the pasture. This will produce increased DM yields, compared with orchardgrass alone, higher quality forage, and favor stand persistence (Lacefield et al., 2003). Similar to alfalfa, cell wall concentration and lignification affect orchardgrass intake and digestibility.

Van Soest Model

A rapid procedure for determining cell wall constituents of plants consists of the determination of the fiber that is insoluble in a detergent solution. The standardization of this method is based on insoluble vegetable matter that is indigestible by proteolytic enzymes and alpha and beta amylase in the rumen. Utilization of this insoluble matter can only be accomplished through microbial fermentation that occurs in the digestive tracts of ruminants. Studies have shown that undigested plant residues in feces of herbivores are composed almost entirely of plant cell wall components, which include hemicellulose, cellulose, and lignin. A procedure based on removal of extractives, followed by enzymatic digestion, should provide a valid criterion for the yield of the components of the preparation. Van Soest et al. (1966) engineered a method to determine the cell wall concentration of forage by using detergent solutions to separate hemicellulose, cellulose, and lignin. This system simulates the degradation of these cell constituents by acids and enzymes present in the rumen (Figure 1.1).

Figure 1.1. Schematic of the detergent forage analysis.[a]

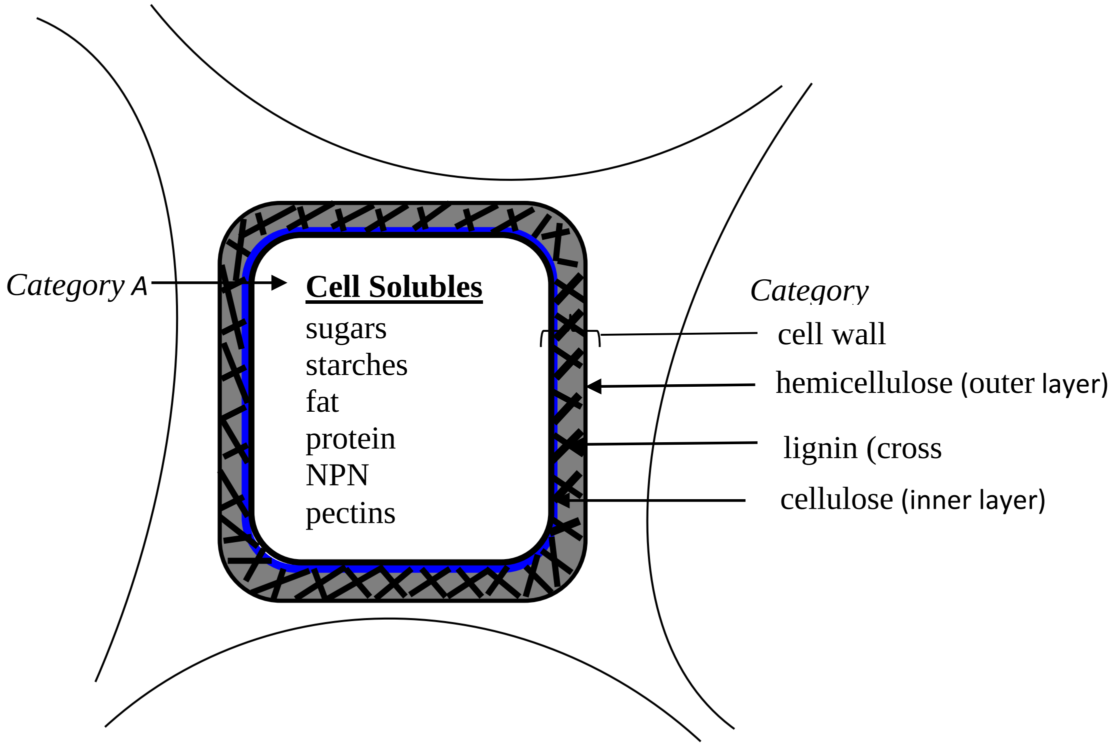


[a] Van Soest et al. (1966).

The sample of interest is ground using a Wiley Mill, generally passing through a 1-mm screen. The ground sample is weighed into a fiber bag and digested with a neutral detergent fiber solution (sodium lauryl sulfate), which totally solubilizes the cell contents that would be completely digested in the rumen. The portion of the sample remaining contains a mixture of hemicellulose, cellulose, and lignin (collectively identified as NDF, neutral detergent fiber). These cell wall constituents are partially or completely indigestible in solution and the rumen. In order to determine the quantity of hemicellulose, the remaining components of the bag are treated with an acid detergent fiber (ADF) solution (trimethylammonium bromide/H_2SO_4). The ADF procedure digests hemicellulosem, but cellulose and lignin remain. Finally, the sample remaining after the NDF and ADF procedure is digested with 72% sulfuric acid. This digests the cellulose, but not the lignin. Lignin is completely indigestible by this procedure, as well as by ruminants, and will never be digested regardless of exposure time to sulfuric acid. Van Soest's detergent system is the method nutritionists use to determine cell wall (fiber) concentration of forages and, in turn, estimate forage quality.

The amount and type of plant cell wall components are important because they influence how extensively a forage can be utilized by animals to produce meat, milk, fiber, and work (Schroder, 2008). A young plant cell has a single outer layer referred to as the primary cell wall. Later, as the plant matures, a second layer is laid down on the inside of the outer cell, known as the secondary cell wall (Schroder, 2008). The main structural components of the primary and secondary walls are cellulose and hemicellulose. Together these components can make up 40 to 80% of the total forage DM (Schroder, 2008). A simplified cell structure is presented in Figure 1.2.

Figure 1.2. Diagram of plant cell showing cell wall structure.[a]



[a] Schroder (2008).

The cell contents (solubles), on the inside, are completely soluble upon reaching the rumen (Schroder, 2008). Components of the cell wall are partially digestible depending upon the cross linkages of lignin. Van Soest et al. (1966) separated the plant cell into two categories, A and B. Category A contains cell solubles that are completely digestible by rumen microflora, while Category B contains the cell wall constituents, hemicellulose, cellulose, and lignin (Table 1.1).

Table 1.1. Classification of forage fractions according to nutritive characteristics.[a]

		Nutritive Availability	
Category	Fraction	Ruminant	Nonruminant
A	1. Sugars, soluble carbohydrate, starch	Complete	Complete
	2. Pectin	Complete	High
	3. NPN	High	High
	4. Protein	High	High
	5. Lipids	High	High
	6. Other solubles	High	High
B	1. Hemicellulose	Partial	Low
	2. Cellulose	Partial	Low
	3. Heat damaged protein	Indigestible	Indigestible
	4. Lignin	Indigestible	Indigestible

[a] Van Soest et al. (1966).

Hemicellulose and cellulose are partially digestible, while lignin is indigestible. With advancing growth and maturity, plant cells convert lignin, a noncarbohydrate, into the primary and secondary walls. This complex compound gives the plant additional strength and rigidity (Schroder, 2008). It is important from a nutritional standpoint because it is an undigestible substance and its presence inhibits the availability of hemicellulose and cellulose to degradation by rumen microorganisms.

Paterson et al. (1994), in a literature review, stated that ruminant productivity is the ultimate measure of forage quality because of its effect on both intake and digestibility. Forage quality can be a function of nutrient concentration, intake, digestibility, and partitioning of metabolized products within animals. Forage fractions can be classified based on their nutritive characteristics. Van Soest (1981) concluded the amount of fiber diets that ruminants can consume varies with the proportion of structural carbohydrates (cell walls). The cell walls, composed chiefly of the structural polysaccharides, cellulose and hemicellulose, are partially degraded by the rumen microflora (Paterson et al., 1994). However, lignin is not degradable. As cell wall concentrations in the plant increase, DM intake, digestible energy intake, DM digestibility, and excretion rate of DM decrease. Concurrently, cell wall intake, rumen fill, and retention time increase. Therefore, rate and extent of digestion of forage DM appears to be related to the indigestible cell wall fraction, the key factor in the control of cell wall turnover and feed intake (Paterson et al., 1994).

Cell Walls

Cell walls make up the majority of the portion of the plant DM that is resistant to degradation by enzymes produced by microorganisms in gastrointestinal tracts of ruminants. Accessibility of the surface of cellulose, the major structural polysaccharide in plants, to cellulolytic enzymes is the primary physical feature influencing enzymatic hydrolysis and cellulose digestion (Stone et al., 1969; Cowling, 1975). Kalu and Fick (1983) found that percentage of NDF, ADF, and lignin of leaf portions generally remains unchanged with increasing stage of maturity. Leaves ranged from 20 to 30% NDF DM, 13 to 22 % ADF DM, and 3 to 6% lignin DM. Leaf stages ranged from vegetative stage to early flowering. However, stem wall constituents did increase with increasing maturity. NDF DM stems were 40 to 50% at the vegetative to 50 to 60% at early bud, ADF DM 33 to 40% to 40 to 50% from vegetative to early bud stage, and lignin increased from 6 to 8% to almost 10% at the early bud stage. Jung and Vogel (1986) tested the hypothesis that lignin inhibits the digestibility of hemicellulose and cellulose. They took five samples from vegetative to heading during primary growth and three samples from vegetative through heading during regrowth. It was concluded that cell wall (CW) was 43.1 to 60.8 %. Cell wall constituents (hemicellulose, cellulose, and lignin) were calculated from percent cell wall. Hemicellulose (NDF) was 42.9 to 55.7%, cellulose (ADF) 40.4 to 52.3%, and lignin 6.6 to 8.1%.

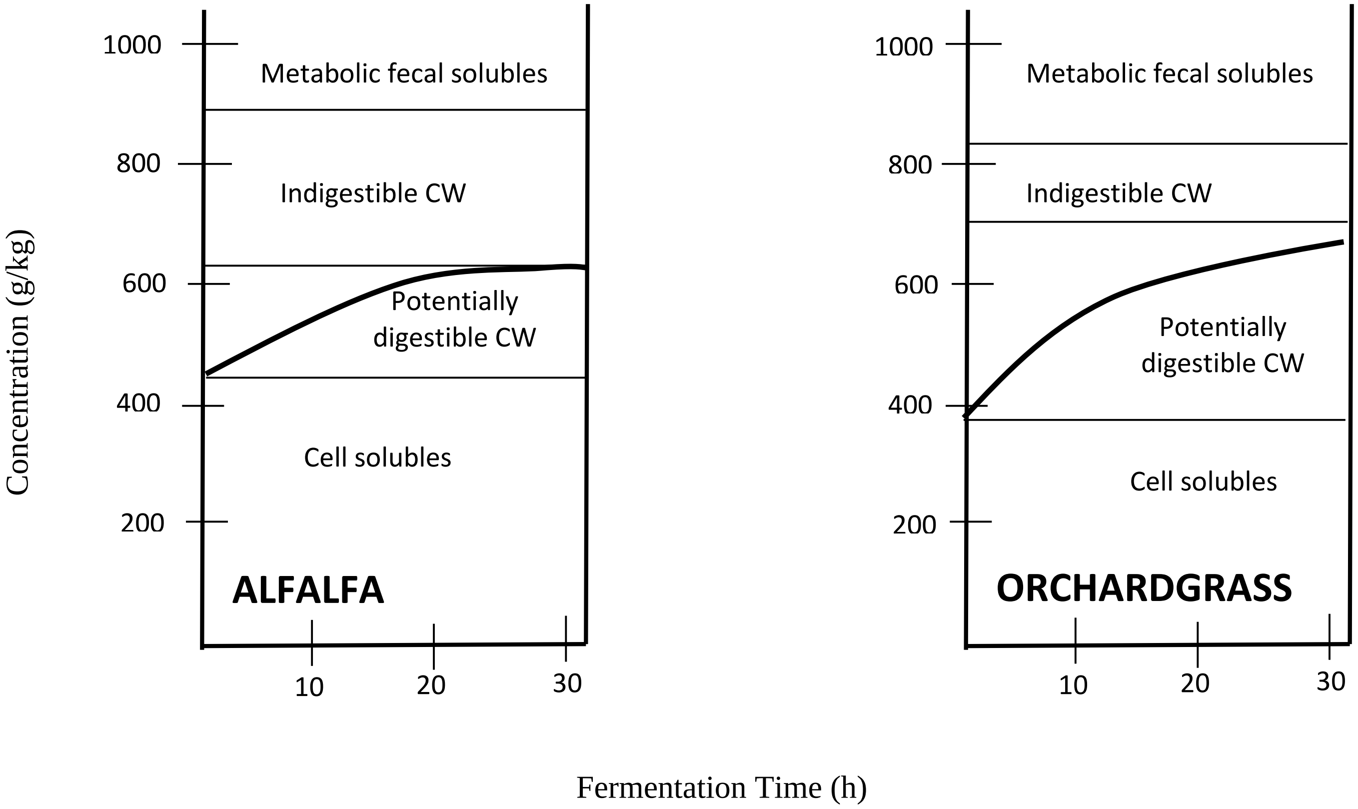
Lignin is composed of monomers interlinked to carbons by ether bonds. These bonds are not susceptible to simple hydrolysis, which increases the difficulty for enzymatic degradation. Lignification occurs mostly in maturing cells that have specialized functions for water conduction and/or mechanical support (Harkin, 1973).

Lignin's low digestibility (Jung and Fahey, 1983) inhibits the digestion of other cell wall polysaccharides (Van Soest, 1981), possibly resulting in undigested lignin residue acting as a bolus in the rumen to reduce forage intake (Waldo and Jorgensen, 1981). Accumulation of undigested feed in the rumen causes the animal to feel satiety, decreasing its desire to graze, and ultimately decreasing forage intake. Lignin is negatively correlated with hemicellulose digestibility. Alfalfa has 50% more lignin that orchardgrass, but has a higher rate of digestion as well as a similar extent of digestion. Low hemicellulose in vegetative alfalfa may be the reason lignin does not have a profound effect on alfalfa digestibility. Lignin appears to inhibit digestion primarily by bonding with hemicellulose (Sullivan, 1966).

Morrison (1979) described a "cage" theory for ligno-hemicellulose complex protection of cellulose from rumen microorganisms and their enzymes. In this hypothesis, the "bars of the cage" (lignin) of young cell walls are theorized to be far enough apart to allow cellulase to access cellulose for degradation. With maturation, the bars grow closer together, restricting the entry of enzymes. In addition, cell walls are not uniformly lignified. It is more concentrated in the corners of cell walls (Adler, 1977). Legumes have a smaller concentration of cell wall compared to grasses, but lignin in alfalfa cell walls is more highly cross-linked than in grasses, resulting in fewer reactive sites available for combining with molecules, such as hemicellulose (Gordon, 1975).

In Figure 1.3, Waldo and Jorgensen (1981) shows that alfalfa contains more cell solubles, approximately the same total cell walls (potentially digestible cell wall plus indigestible cell wall), and less metabolic fecal solubles than orchardgrass. This figure illustrates the main difference between these two forages is the concentration of potentially digestible and indigestible CW. Increased lignification and indigestible CW, results in decreased availability of digestible polysaccharides, hemicellulose and cellulose, to enzyme degradation. The lower concentration of potentially digestible cell wall, hemicellulose and cellulose, in alfalfa compared with orchardgrass, results in greater concentrations of cell solubles available for digestion. This causes a faster rate of digestibility and an increase of intake. It also decreases the amount of metabolic fecal solubes, allowing the animal to utilize more nutrients provided by the forage.

Figure 1.3. Comparison of the sources of digestible DM and digestion rates for potentially digestible cell walls in alfalfa and orchardgrass and their effect on digestibility as fermentation time changes.[a]



[a]Waldo and Jorgensen (1981).

Neutral Detergent Fiber (NDF)

Van Soest's detergent system uses NDF as an indicator of the cell wall concentration and is negatively related to the intake potential of forages. Total alfalfa DM herbage contains 40% NDF, but rarely do sheep consume an entire alfalfa stand uniformly. Instead, they select different parts of the alfalfa shoot, which affects intake and passage rate. They prefer the highly digestible portions because the delay between beginning to eat and nutrient availability is short. Knowing that sheep select leaves before stems, it is important to consider the difference in NDF of different parts of the forage. Alfalfa DM harvested at early bud has lower NDF (39.7%) than full bloom (50.8%). Likewise, the NDF of vegetative orchardgrass DM is lower (57.3%) than at anthesis, or flowering (68.1 %) (Balde et al., 1993). Collins (1988) showed the upper portion of the alfalfa stem DM is lower in NDF (52.6%) than the lower stem (67.8%). Still, the lower stem is higher than the upper leaf fraction which is 27.7%. Buxton et al. (1985) found the NDF concentration of orchardgrass stem DM to be 70%, compared with flowering plants at 50%.

Collins (1988) stated "the higher rate of NDF disappearance, especially stem tissue, contributes to the rapid removal of NDF from the rumen and potentially to higher intake". In alfalfa, upper stem was lower in NDF than lower stem, but was still much higher in NDF that upper leaf fraction. The NDF fraction from alfalfa had a significantly lower disappearance after 72 hr incubation compared to timothy. In a study of several species, alfalfa NDF disappearance rate was found to be higher than orchardgrass. Alfalfa NDF was digested in vitro at a rate of 9.0%/h higher than orchardgrass with 6.2%/h. The low value for stem NDF disappearance wase primarily responsible for the lower NDF disappearance found for alfalfa than for timothy. The low concentrations of NDF in alfalfa and the resulting low levels of undigested NDF residues after short fermentation times are important factors in achieving the high consumption levels observed for forage of that species (Waldo and Jorgeson, 1981). In order to achieve high intake levels, other factors must offset the relatively low digestibility observed for the NDF fraction of alfalfa compared with grasses.

Acid Detergent Fiber (ADF)

ADF is negatively related to digestibility of forages (Schroder, 2008). Therefore, nutritionists can use ADF to predict digestible energy of forages. Alfalfa, which is considered a “good” quality forage has 29 to 32% ADF on a DM basis (Putnam and Undersander, 2006). Like previously described with NDF, content of different parts of the alfalfa shoot, ADF should be described similarly because it also contains the cellulose and lignin. However, ADF does not contain hemicellulose. Forage cellulose digestibility can vary from 25 to 90% (Pigden and Heaney, 1969; Moore and Hatfield, 1994). When comparing alfalfa with orchardgrass, Keys et al. (1969) determined that, in ruminants, alfalfa cell walls were not as digestible as grass cells walls. The amount of lignin in alfalfa cell wall is greater, therefore grass cell walls are more digestible. Therefore, the digestion coefficient of cell wall in alfalfa (35.4%) is less than orchardgrass cell wall (45.7%).

Forage Maturity

In addition to cell wall composition, maturity of the plant plays a vital role in its digestibility. Popp et al. (2000) summarized studies by Karnezos et al. (1994), Beauchemin and Iwaasa (1993), and White and Wight (1984) that shows as alfalfa matures, CP decreased and ADF increased. ADF identifies the amount of cellulose and lignin present, meaning the larger the ADF concentration, the lower the in vitro digestibility prediction. Christie and McElroy (1995) reported, with orchardgrass in the spring, that DM yield increased, while quality, as measured by crude protein (CP) content and leaf in vitro DM digestibility (IVDMD) decreased as the orchardgrass matured. Unless properly managed, orchardgrass matures quickly in the early summer, becoming coarse and unpalatable. Fulkerson (1983) found the IVDMD of orchardgrass drops rapidly after anthesis (flowering) and at early seed set was about 52%.(Table 1.2.) (Fulkerson, 1983; Christie and McElroy, 1995).

Table 1.2. Yield, in vitro digestibility (IVDMD), and crude protein (CP) of orchardgrass at five stages of maturity.[a]

	Orchardgrass		
Stage	DM yield (kg/ha)	IVDMD (%)	CP (%)[b]
Early vegetative	2,016	76.4	23.2
Boot	2,874	74.7	13.3
Heading	3,911	71.2	11.0
Anthesis	5,115	61.3	8.2
Early seed	5,958	51.8	6.6

[a]Fulkerson (1983).
[b]DM basis

Orchardgrass and orchardgrass/legume mixtures have high yield potentials, but must be managed properly. With the addition of legumes, such as alfalfa, orchardgrass stands become more productive and last longer, especially when the alfalfa is heavily fertilized and cut frequently. A comparison of alfalfa and orchardgrass chemical compositions at different stages of maturity can be seen in Table 1.3.

Table 1.3. Chemical analysis of alfalfa and orchardgrass forage.[a]

Forage	DM	CP[b]	NDF[b]	ADF[b]
Alfalfa				
Early bud	92.3	25.2	39.7	29.9
Early bloom	92.5	23.2	42.4	31.6
Mid bloom	92.0	18.7	47.7	35.0
Full bloom	92.4	18.3	50.8	37.7
Orchardgrass				
Vegetative	92.3	20.2	57.3	28.6
Early head	92.1	20.6	58.3	29.7
Full head	92.2	15.4	63.9	31.7
Anthesis	92.3	12.7	68.1	36.9

[a] Balde et al. (1993).

[b] DM basis.

The CP decreases as NDF and ADF increase with maturity of both forages. If higher concentrations of NDF and ADF are inversely related to higher quality, then the quality of both forages decrease as they mature. Table 1.4 shows that as orchardgrass yield increases throughout the grazing season, leaf percentage decreases, indicating the decrease in forage quality (Fulkerson, 1983). This is verified with the decrease in CP and IVDMD. Although dry matter yield increases as summer progresses the quality of the forage becomes less.

Table 1.4. Yield, proportion of leaves, IVDMD, and CP of orchardgrass spring forage in Guelph, Canada.[a]

Date	DM yield (kg/ha)	Leaf (%)	IVDDM (%)	CP (%)
May 7	535	100	76.4	28.0
May 14	1,099	100	75.0	23.2
May 22	2,016	90	76.4	16.0
May 28	2,849	77	76.0	13.0
Jun 4	4,008	59	72.0	10.8
Jun 11	4,627	52	65.0	9.2
Jun 18	4,997	53	61.9	8.4
Jun 25	5,473	47	56.9	7.5
Jul 3	5,570	47	53.5	6.9
Jul 9	5,760	50	52.4	6.6
Jul 11	5,707	49	49.7	6.1
Jul 23	5,185	53	46.3	6.2

[a] Fulkerson (1983).

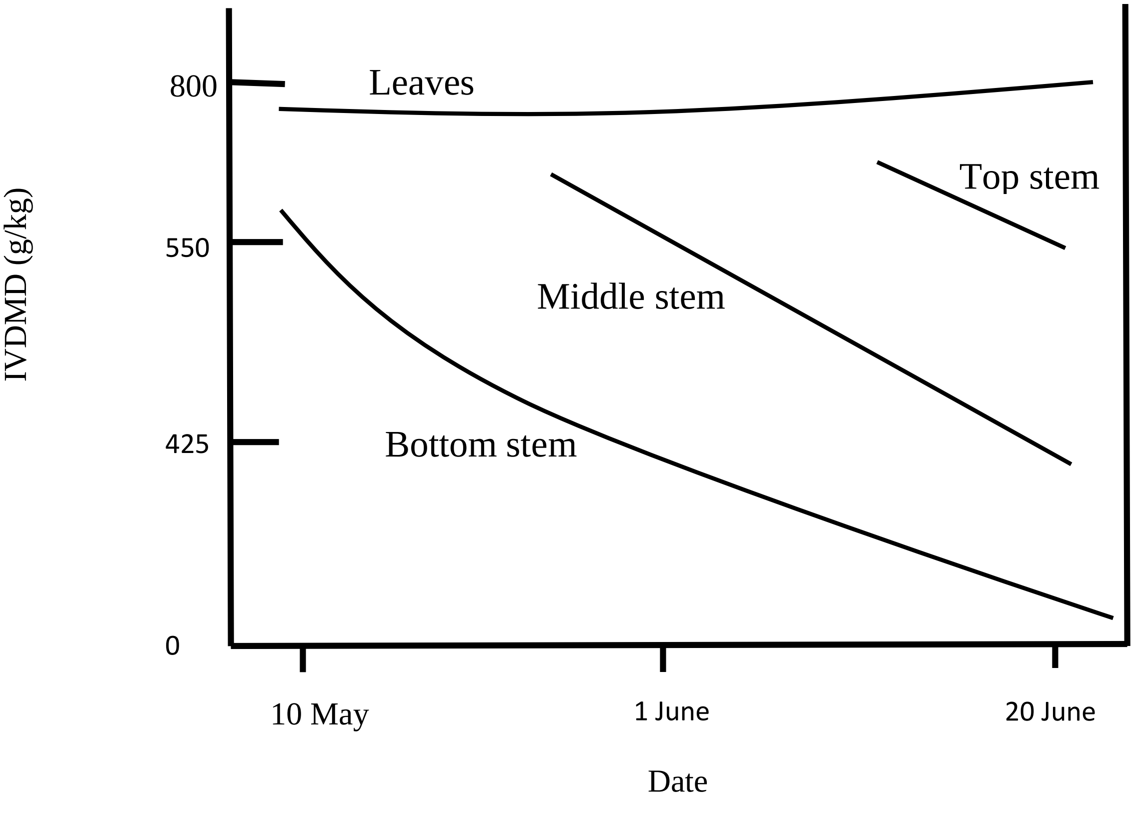
Leaf versus Stem

Alfalfa leaves have similar nutritive values in the early stages of maturity. They have a higher nutritive values than stems throughout the maturation process. As alfalfa matures, stem mass increases causing the leaf to stem (L:S) ratio to narrow resulting in a decrease in nutritive value. Albrecht (1983) reported that L:S narrowed from 1.4:1 in the late vegetative stage to 0.7:1 by the early pod stage. Onstad and Fick (1983) found the L:S of spring growth alfalfa to be narrower than regrowth throughout the grazing season at same morphological stage, meaning early bud alfalfa at first cutting will have more leaves than early bud alfalfa at second cutting. This indicates alfalfa will have more leaves, compared with stems, early in the grazing season (spring) and will be of higher quality.

Work done by Buxton et al. (1985) demonstrated that leaves have a higher CP content, as well as IVDMD, than stems. Based on total leaf herbage, Anderson et al. (1973) had found earlier that IVDMD alfalfa of spring growth decreased 1.4% with each

1.0% decrease in CP content. They also reported that intake, by sheep, of first cutting alfalfa hay was reduced 0.21 g/kg $BW^{0.75}$ for each day harvest was delayed after the vegetative stage in May. Hardison et al. (1957) found digestibility of lower portions of stems decreased at a rate of 0.6% per day and was only 87% as digestible as the upper portion. Buxton et al. (1985) had reported that variation in amount of cell wall and lignin concentration accounted for 95% of the variation in IVDDM among stem segments. These results are shown in Figure 1.4.

Figure 1.4. Changes in IVDMD of alfalfa leaves and stem segments during maturation of spring growth.[a]



[a]Buxton et al. (1985).

As the grazing season moves from spring (10 May) to summer (20 June), IVDMD decreases for the stand. The most obvious decrease is seen in bottom (650 to 450 g/kg) and middle stem portions (700 to 500 g/kg). The highest IVDMD is found in leaves, throughout the grazing season.

Protein

Nitrogen (N) in forages can be categorized into true protein and nonprotein nitrogen (NPN). The majority of herbage N is in the form of true protein (60 to 80%), whereas the NPN consist of nucleic acids, free amino acids, amides, and nitrate. When true protein enters the rumen, it can be degraded by proteolytic enzymes, produced by microorganisms, into peptides and amino acids (NPN). These products can then be assimilated into microbial protein or deaminated and metabolized into energy (Buxton and Mertens, 1995). Pearson and Smith (1943) were among the first to clearly show that both synthesis and breakdown of protein occur in the rumen. Peptides and amino acids are attacked by deaminases, producing ammonia, which can converted into microbial protein if energy, in the form of carbohydrates, is available (Annison and Lewis, 1959). If ammonia production is excessive or if carbohydrate energy is limited, ammonia will be absorbed across the rumen wall. As ammonia enters the bloodstream, it is transported to the liver where is it can be converted to urea. Some urea can be recycled back through the saliva into the rumen, but the majority is excreted through the urine. Adding a concentrate energy source, such as corn, wheat, barley, oats, or milo, can increase forage protein utilization because more ammonia is captured to produce more microbial protein therefore preventing excessive ammonia absorption across the rumen wall (Annison and Lewis, 1959; Buxton and Mertens, 1995). On average, 75% of dietary forage protein is degraded by microbes, while 25% escapes ruminal fermentation and passes to the abomasum (Buxton, 1995). Utilization of the 75% degraded depends on how much of the ammonia is captured into microbial protein before passing to the abomasum.

Ruminal microbial protein synthesis can be limited by a lack of forage energy. Then, optimum performance of ruminants during rapid growth, late pregnancy, and early lactation may be compromised (Buxton and Mertens, 1995). Rumen microbes have the ability to modify and supplement the amino acids of the ingested protein and therefore, alter the amount of N that becomes available to the ruminant (Purser and Buechler, 1966). Due to the presence of ruminal microorganisms, protein quality is dependent on the availability of amino acids leaving the rumen rather than the ingested diet. In addition, it is a distinct ruminant advantage to have the ability to utilize N from both dietary protein and NPN sources.

Energy

Sachse (2013) states that insufficient energy limits performance of sheep more than any other nutritional deficiency. An energy deficiency can result from inadequate amounts of feed or a deficiency in the feedstuff(s) consumed, generally in forages. Deficiencies can lead to reduced growth rate, loss of weight, reduced fertility, lowered milk production, and reduced wool quality and quantity (Sachse, 2013). From an energy standpoint, carbohydrates are most important, because they provide up to 80% of the energy required by ruminants (Buxton and Mertens, 1995). In forages, energy is provided primarily in the form of carbohydrates and to a lesser degree, as lipids. The carbohydrates are primarily in the form of “fiber” (cell walls that contain cellulose and hemicellulose;

NDF and ADF). More than 90% of carbohydrate digestion occurs within the rumen (Armstrong and Smithard, 1979; Sutton, 1979). However, if passage rate is high, a significant amount of carbohydrate digestion can occur in in the intestines (Hoover, 1978; Nocek and Tamminga, 1991). Rapid fermentation of simple sugars in the rumen produces volatile fatty acids (VFA) that are absorbed through the rumen wall into the bloodstream (Morrison, 1979; Baldwin and Allison, 1983; Moore and Hatfield, 1994). Starch and fructans (nonstructural polysaccharides) are also rapidly fermented to simple sugars and then VFA (Nocek and Tamminga, 1991; Moore and Hatfield, 1994), while degradation of structural polysaccharides varies. Provision of dietary energy and protein sources that are fermented in synchrony stimulates ruminal microbial protein synthesis and subsequently increases the digestibility of diet DM.

Sultan et al. (2010), fed lambs four diets: high energy-low protein diet (HE-LP), high energy-high protein (HE-HP), low energy-low protein diet (LE-LP), and low energy-high protein diet (LE-HP). It can be seen in Table 1.5. that DMI was highest ($P < 0.05$) in lambs fed LE-HP.

Table 1.5. Nutrient intake and digestibility in lambs fed varying energy and protein levels.[a]

Energy Level	Low		High	
Protein Level	Low	High	Low	High
DM intake (g/d)	1,201.0^{c}	1,342.0^{b}	1,120.0^{d}	1,155.0^{c,d}
N intake (g/d)	22.9^{d}	30.2^{b}	21.5^{e}	25.9^{c}
NDF intake (g/d)	424.0^{b}	426.0^{b}	274.4^{c}	365.0^{c}
DM digestibility (%)	63.5	65.6	71.4	73.6
N digestibility (%)	57.9^{d}	63.2^{c}	57.3^{d}	65.3^{b}
NDF digestibility (%)	65.5	64.5	58.4	57.1

[a] Sultan et al. (2010).

[b,c,d] Values on the same line with different superscripts differ ($P < 0.05$).

Increasing dietary energy resulted in decreased dry matter intake (DMI). DMI was 7.1% greater by the animals fed high-protein (14%) diet than those fed low-protein (12%) diets. ADG was increased ($P < 0.01$) with increased dietary CP level from 12% to 14%. Increasing energy supply increases the efficiency of protein utilization (Schroeder et al., 2006; Schroeder, 2006b) and improves feed to gain ratio in sheep fed high energy and high protein.

Lamb Breeds

An interest in hair sheep has developed throughout the United States due to increased costs of shearing along with a decreased interest in the market place for wool. Developed in South Africa in the 1930s, Dorpers are a hair breed. They were developed from an original cross between a Horned Dorset ram and Blackhead Persian ewe. This is a small framed, muscular bodied breed that as a white body and a black face. They are one of the most fertile breeds of sheep and have a short light covering of hair and wool primarily over the backbone. In addition, the breed demonstrates exceptional adaptability, hardiness, reproduction rates, growth, and mothering abilities. White Dorper characteristics are similar to those of the Dorper, the main difference being a white instead of a black head. Like the Dorper, the White Dorper is well adapted to a variety of climatic and grazing conditions and has the ability to raise a lamb of quality under harsh range conditions (dry, hot, and limited feed) where other breeds are unable to survive (OSU, 1995). Mature ram weights (White Dorper and Dorper) range from 225 lb to 275 lb, while ewes, White Dorper and Dorper, in this breed average 170 lb to 200 lb (SID, 2002).

The Polypay is a composite breed developed from the Targhee, Rambouillet, Polled Dorset, and Finnish Landrace at the US Sheep Experiment Station in Dubois, Idaho. They are a medium-sized, prolific, white face breed. In addition, ewes have some out-of-season breeding abilities. They are known for being good mothers and milkers, which produce lambs with good growth and carcass qualities. Polypays are most appropriate for high feed producing geographical areas. Mature rams of this breed range weigh from 180 lb to 240 lb, while ewes weigh 130 lb to 180 lb (SID, 2002).

Animal Gains

Production systems that promote rapid lamb growth, such as lambs in a drylot, usually result in more efficient feed utilization (McClure et al., 1994). However, free choice of concentrate in drylots has led to fatter lambs than those raised on pasture (Ely et al., 1979; Arnold and Meyer, 1988; Notter et al., 1991). Blackburn et al. (1991) indicated there could be some benefits to grazing lambs on high-quality pasture before sending them to the feedlot. As forage intake increased from 1.5 to 2.5% of the animal's body weight, gain increased from 0.1 kg/d to 0.77 kg/d. In many production settings, supplementary nutrients are necessary to obtain acceptable levels of performance from forage-fed animals. Nutrition studies have also indicated potential for manipulation of carcass composition. Because many of the breed or nutrition differences are small; combination of breed, nutrition, and management should yield greater effects (Blackburn et al., 1991). Paterson et al. (1994) stated that a supplementation strategy could be used to increase forage use by maximizing forage intake and digestion.

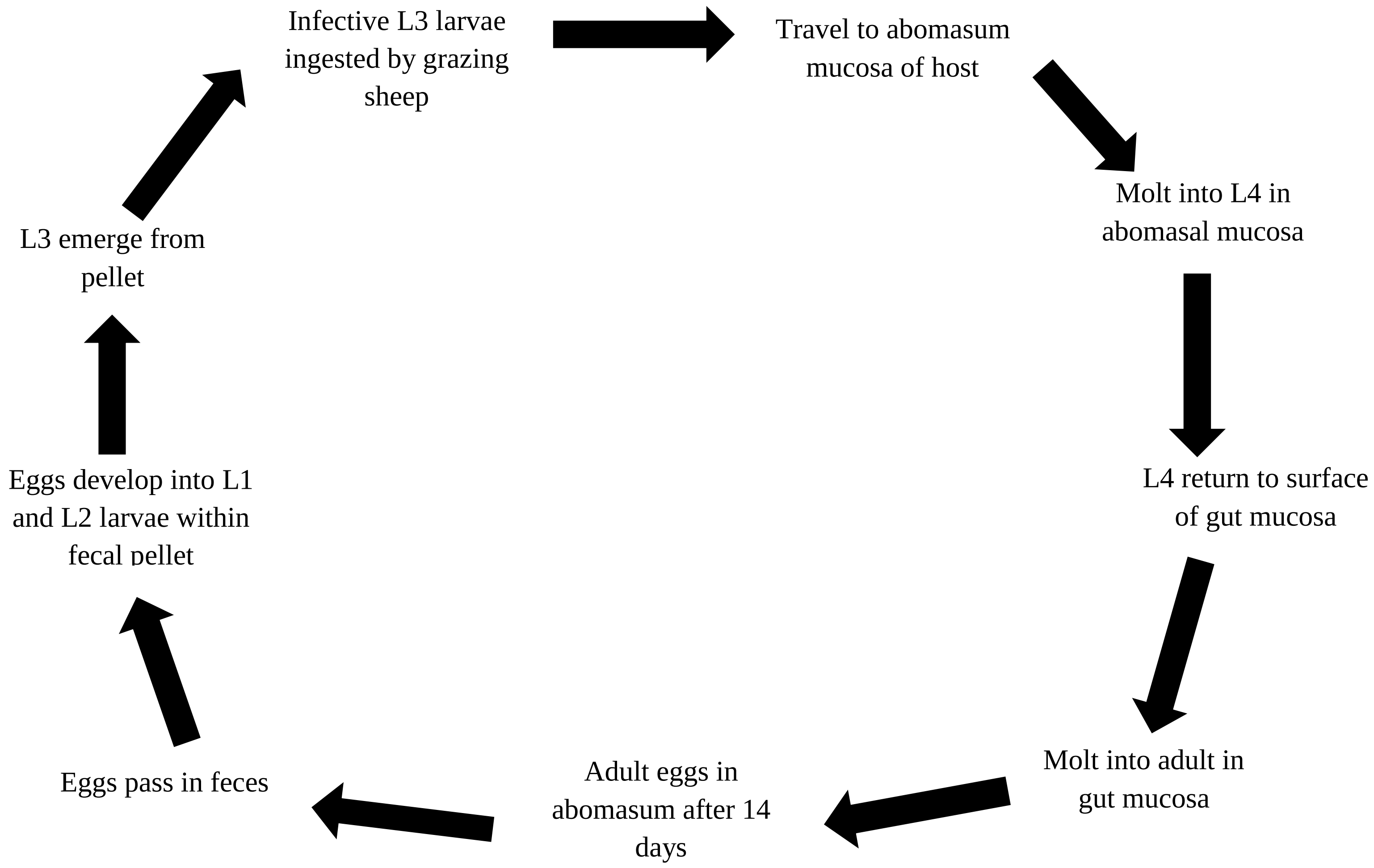
Data have also shown that grazing legumes can have an effect on gains that are similar to lambs fed in drylot. Van Keuren (1985) found that lambs grazing legumes, such as alfalfa, had higher ADG than lambs grazing grasses. Although it is accepted that lambs fed high-concentrate diets, in drylot, have higher gains than lambs grazing grass pasture (Ely et al., 1979; Arnold and Meyer, 1988; Notter et al., 1991), McClure et al. (1994) countered that these differences may depend on climate conditions and quality of the alfalfa. McClure et al. (1994) concluded finishing lambs on alfalfa results in a lean lamb with desirable carcass characteristics, comparable to lambs finished in drylots.

When grazing livestock on alfalfa, low dietary energy values are of concern. Consumption of an unbalanced alfalfa diet can result in high concentrations of free ammonia nitrogen, which can be absorbed through the rumen wall to enter the blood stream. Then, it can be recycled as urea, through saliva, or excreted through the urine (Dellow, 1988; Hammond, 1992; Karnezos et al., 1994). Free ammonia nitrogen decreases the microbial synthesis potential from alfalfa and in return can decrease animal gains (Karnezos et al., 1994). Kennedy and Milligan (1980) hypothesized that supplementing corn to lambs grazing alfalfa would increase urea utilization and increase microbial protein synthesis.

Internal Parasites

Burke et al. (2012) stated that gastrointestinal nematode parasitism is the most serious constraint affecting sheep production all over the world. The nematode of particular interest is *Haemonchus contortus,* which can cause severe blood loss that results in anemia, weight loss, loss of condition, and possibly death (Miller and Horohov, 2006). In order for parasites to complete a life cycle, nematodes have to develop and lay eggs in the host. The host will become infected by consuming third-stage larvae living on forage leaves during grazing. After ingestion, larvae of *H. contortus* lose their protective sheath and invade the mucosa of the abomasum. Once in the mucosa, larvae develop into the fourth larval stage and return to the surface of the mucosa where they become adult worms (Miller and Horohov, 2006). This cycle can be seen in Figure 1.5.

Figure 1.5. Lifecycle of Haemonchus contortus.[a]



[a] Adapted from Hempworth et al. (2006) with incorporated information from Miller and Horhov (2006).

Temperature and moisture are the dominant influences on free-living stages of *H. contortus*, with the effects of pasture conditions playing a significant role in modulation (O'Connor et al., 2006). The length and development cycle is largely dependent on the temperature, with warmer temperatures causing an increase in development rate. In addition, moisture is needed in order for the developmental stage to proceed to the infective larval stage. The parasite is most susceptible during the pre-infective stage. Once the larvae reach the infective stage, the influence of temperature and moisture on survival decrease (O'Connor et al., 2006).

Nutrition has a major effect on both resistance of grazing animals to *H. contortus* and on resilience to the effects of infection (Coop and Holmes, 1996; Coop and Kyriazakis, 1999; Burke et al., 2009). Supplementation with protein is associated with reduced fecal egg counts in lambs (Gibson, 1963; Shaw et al., 1995). Protein supplementation also offsets the increase in protein turnover and lack of appetite seen in haemonchosis (Abbott et al., 1986, 1988). These researchers concluded that weaned lambs fed a 17% CP supplement developed immunity to a trickle infection of *H. contortus*, whereas lambs fed an 8% CP supplement showed no protection.

Lambs are more subject to infestation when signs of infection, such as diarrhea, weight loss, and bottle jaw (edema), can be seen. Signs of infestation are less common in mature animals due to a better immune system (Manton et al., 1962; Benitez-Usher et al., 1977; Miller and Horohov, 2006). The development of immunity is also influenced by gender, breed, and dietary protein content (Stewart, 1953; Dobson and Bawden, 1974; Abbott et al., 1986, 1988; Brown et al., 1991; Wallace et al., 1995; Wallace et al., 1996) and age at weaning (Spedding et al., 1963). In a study conducted by Schichowski et al.

(2010), eighty purebred single-born Merino lambs were used to determine the effect of age at weaning on weight gains with stomach worm infestation. All lambs were born inside a barn on straw. At the age of 4 weeks, ewes and their lambs were randomly allotted to four groups of 20 ewes each. Group 1 was weaned at 6 weeks and infected with *H. contortus* at 13 weeks of age. Group 2 was not weaned until the end of the experiment (at 21 weeks of age) but were infected with *H. contortus* at 13 weeks of age. Group 3 was infected and weaned at 13 weeks of age. Group 4 was weaned at 13 weeks, but was not infected and was kept as the control group. Groups 1,2, and 3 were orally infected with 5,000 infective stage larvae. At the age of 13 and 17 weeks, ADG was significantly different ($P < 0.01$) among the groups with the highest values in animals from groups 3 and 4 (infected at 13 weeks). However, ADG until 21 weeks of age was significantly different ($P < 0.05$) between groups 2 and 3.

Due to increased anthelmintic resistance, there has been an increased interest in identifying breeds that possess genetic resistance to or tolerance for nematode infection (Notter et al., 2003). Particularly high levels of resistance to gastrointestinal nematodes have been reported in Caribbean hair sheep (Zajac, 1995). These breeds and their ancestral populations in Western Africa ((Bradford and Fitzhugh, 1983)) are a particularly significant genetic resource for the development of parasite resistant lines of sheep (Notter et al., 2003). Notter et al. (2003) compared fecal egg counts (FEC) of early-weaned hair (Barbados Blackbelly and Virgin Island White) and wool type lambs (50% Polled Dorset x 25% Rambouillet x 25% Finnish Landrace). Lambs were weaned at an average of 62 days. He found FEC at week 4 post-weaning lower in hair type lambs than in the wool type. FEC of hair lambs peaked at week 5 at approximately half the levels observed in wool lambs and the decline after week 5 was consistent and relatively rapid. Hair type ewe lambs had higher FEC (2024 ± 510 eggs/g) than hair ram lambs (632 ± 150 eggs/g). However, in wool lambs, FEC (eggs/g) were nearly the same for rams (3395 ± 467) and ewes (4031 ± 552). This result is consistent with breed differences in egg production during this post-weaning period.

Chapter III

Materials and Methods

Pre-experiment Lamb Management

Pre-weaning data (birth dates, birth weights, type of birth, 30-day weights, and 60-day weights) were collected on 150 and 152 (Year 1 and 2, respectively) Polypay (PP) and White Dorper (WD) lambs born during the month of April 2012 (Year 1) and 2014 (Year 2). Lambs nursed ewes grazing fescue/orchardgrass/bluegrass pasture and had ad libitum access to a creep diet of 80% ground/cracked corn: 20% protein supplement (40% CP) from birth until weaning at an average of 60 days (June 13 in Year 1 and June 19 in Year 2). All lambs received a *Clostridium perfingens* Type C, D and *Clostridium tetani* at 5 weeks of age and at weaning to prevent enterotoxemia and tetanus. Lambs remained in their pre-weaning environment for 7 days in Year 1 and 11 days in Year 2 before allotment to the experiment. After the adjustment period, but before being placed in treatment groups, lambs were dewormed with Cydectin (Year 1) and Tramisol (Year 2) in an effort to eliminate stomach worm (*Haemonchus contortus*) infestation that may have built up during the 60-day pre-weaning period.

Wether and ewe lambs were randomly allotted, by weaning weight within breed (PP and WD), to two supplementation treatments (S = supplemented at 2% BW daily and US = unsupplemented) for two summer grazing season in Year 1 and 2. Breed and gender of supplemented and unsupplemented lambs are shown in Table 2.1. Eighty-three PP and 67 WD lambs were used in Year 1. Of the 83 PP, 42 (18 wethers and 24 ewes) were supplemented and 41 (16 wethers and 25 ewes) were unsupplemented in Year 1. Seventeen WD wethers and 16 ewes were supplemented (33 total) as 15 wethers and 19 ewes were unsupplemented (67 total) in Year 1. Numbers were similar in Year 2 (Table 2.1).

Table 2.1. Gender of Polypay and White Dorper supplemented and unsupplemented lambs in two summer grazing seasons.

Year[a]	1		2	
Breed[b]	PP	WD	PP	WD
Sex/Supplement[c]				
Wethers				
S	18	17	20	14
US	16	15	16	15
Ewes				
S	24	16	23	19
US	25	19	27	18

[a] Year 1 = 2012; Year 2 = 2014.
[b] PP = Polypay; WD = White Dorper.
[c] S = supplemented; US = unsupplemented.

Supplementation and Grazing Strategy

Initial weights were recorded on June 20 in Year 1 and June 30 in Year 2. Thereafter, lambs were individually weighed and rectal fecal samples were taken for *H. contortus* egg counts at 14-day intervals until September 11 in Year 1 and September 22 in Year 2. Interim weigh dates (days) are shown in Table 2.2.

Table 2.2. Experimental weigh dates (days).

	Year	
Day	1	2
1	Jun 20	Jun 30
2	Jul 03	Jul 14
3	Jul 17	Jul 28
4	Jul 31	Aug 11
5	Aug 14	Aug 25
6	Aug 28	Sep 08
7	Sep 11	Sep 22

Although weigh dates were not the same each year, weigh days 1 through 7 correspond to specific dates within a year. Then, weigh periods one through six in Table 2.3 correspond to the 14-days between each weigh date (day). For example, weigh period one is the number of days between weigh date (days) one and two (Jun 20 to Jul 3 in Year 1 and Jun 30 to Jul 14 in Year 2).

Table 2.3. Experimental weigh periods.

	Year	
Period	1	2
1	Jun 20 to Jul 03	Jun 30 to Jul 14
2	Jul 03 to Jul 17	Jul 14 to Jul 28
3	Jul 17 to Jul 31	Jul 28 to Aug 11
4	Jul 31 to Aug 14	Aug 11 to Aug 25
5	Aug 14 to Aug 28	Aug 25 to Sep 08
6	Aug 28 to Sep 11	Sep 08 to Sep 22
Overall	**Jun 20 to Sep 11**	**June 30 to Sep 22**

The overall periods in Table 2.3 are in the inclusive dates (days) from June 20 to September 11 in Year 1 and June 30 to September 22 in Year 2. Figures 2.1 and 2.2 illustrate that all lambs were individually weighed and fecal samples obtained for *Haemonchus contortus* fecal egg counts (FEC) at 14-day intervals during the 80- and 85-day grazing seasons in Years 1 and 2, respectively. These figures further denote the deworming regimes of both years, which were based on a combination of fecal egg count (FEC) and visual observation (weight loss, slow gain, and/or anemic features) of each lamb. SometimeS an analysis of determining whether lambs needED deworming or not was made at 14-day intervals. Other times it was made subjectively within a 14-day interval.

If the FEC were greater on a weigh date than on the previous date and lambs exhibited visual signs of infestation, they were dewormed. Each deworming exercise proceeded as follows: lambs were moved from pasture and fasted for 16 h in drylot. After deworming, they were fasted an additional 3 h and supplemented lambs were offered their daily allotment of supplement plus 0.25 kg grass hay/lamb before returning to pasture. Unsupplemented lambs were offered 0.25 kg grass hay/lamb before returning to pasture.

Figure 2.1. Experimental timeline for Year 1.

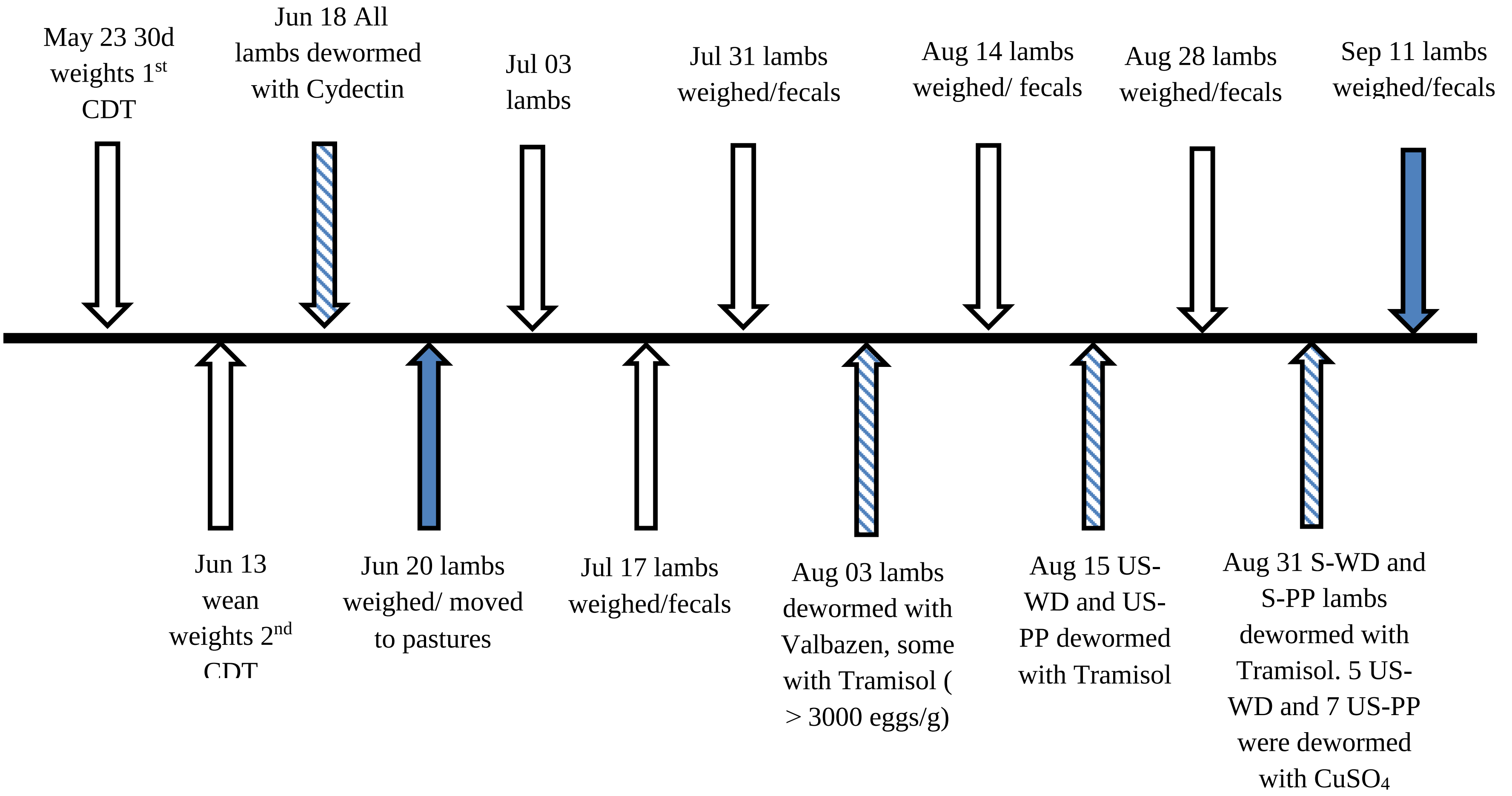
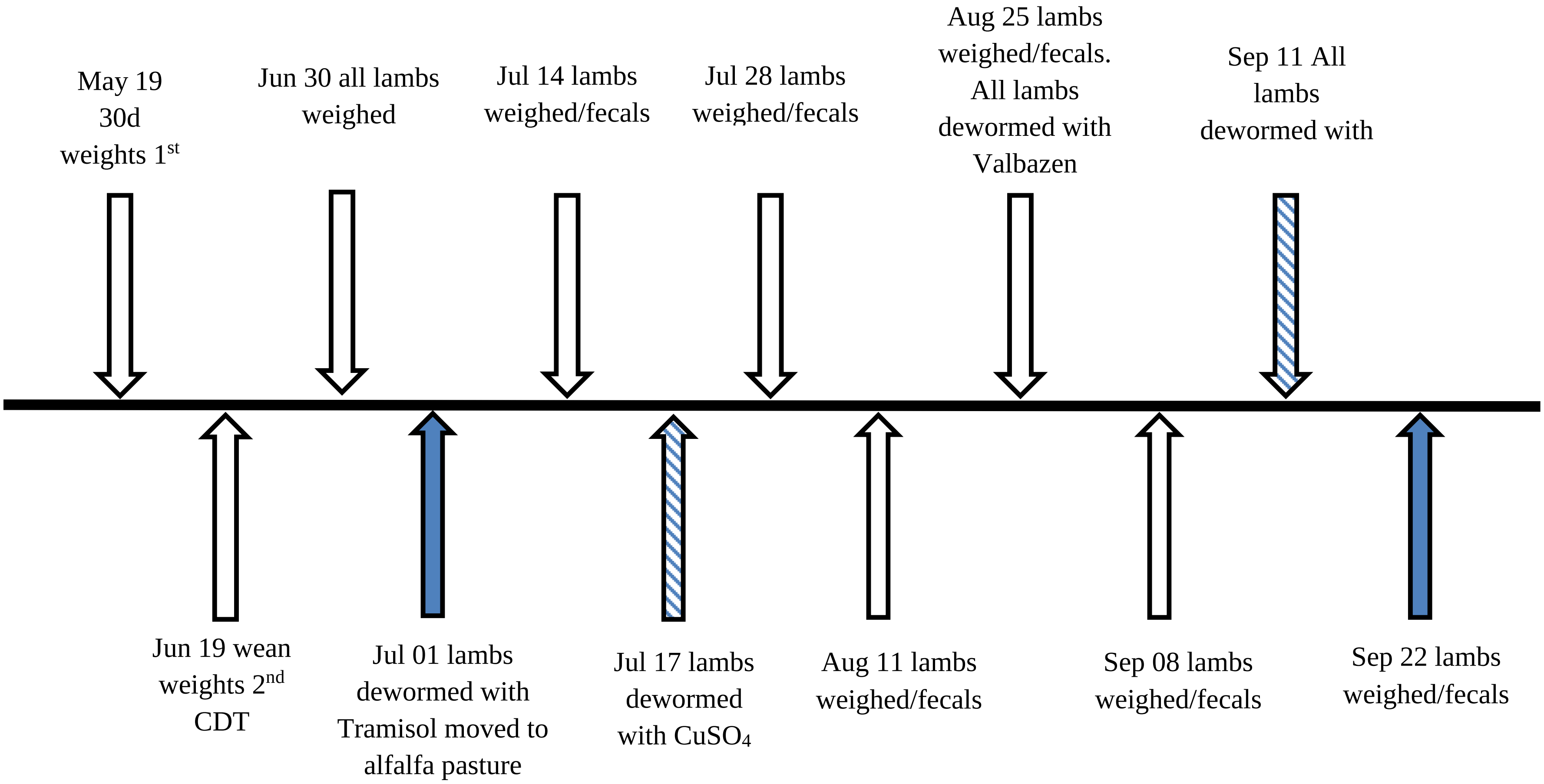


Figure 2.2. Experimental timeline for Year 2.



Supplemented lambs were fed once daily between 0700 and 0800 h, except on weigh days. On these days, lambs were fed after they were weighed and returned to their assigned pastures. Each supplemented group received the same amount on the weigh day and the following. Then, the amount of supplement offered was gradually increased to 2% BW (average of group 2 days previous) daily and held at this level until the next weigh date. Ingredient composition of supplement provided to lambs can be seen in Table 2.4.

Table 2.4. Ingredient composition of supplement.

Ingredient	%
Gr./Cr. Corn[a]	80
Protein pellet[b]	20

[a]Ground through a hammer mill without a screen.
[b]40% CP.

The grazing season was 80 days long in Year 1 (Jun 20 to Sep 11) and 85 days in Year 2 (Jul 1 to Sep 22). Lambs were rotated through 12, 0.5 ha alfalfa/orchardgrass plots throughout the grazing season. Rotation from plot to plot was based on forage availability, forage quality estimation, and length of time lambs had grazed in a specific plot. After lambs were moved, plots were mowed to 7.6 to 12.7 cm height to allow uniform regrowth. Lambs grazed in these plots until they reached target end weights (PP = 54.5 kg; WD = 45.5 kg) or until the end of the grazing season (Sep 10 in Year 1; Sep 22 in Year 2). End weights are those recommended by Aaron et al. (2009) when Polypay and White Dorper lambs will yield carcassES that contain maximum lean and optimum fat.

Data Collection

Fecal samples were analyzed for *H. contortus* egg concentrate (eggs/g) using the McMaster technique (Whitelock, 1948). A subsample of 2 g fresh feces was mixed with 28 mL of a solution containing equal part sugar and water (v/v). The resulting slurry was strained through a tea strainer. A 0.15 mL aliquot of filtrate was added to each of the two grids of McMaster counting slide (Paracount-EPG, Olympic Equine Products, Issaquah, USA). After 5 min, the number of eggs of each grid were counted under a microscope at 40x magnification. Each egg counted represented 50 eggs/g of feces (FEC).

A metal frame (21.3 x 61.0 cm) was used to collect forage samples so an estimation of forage DM could be made (Figure 2.3). Five samples were collected from each plot as lambs exited a grazed plot (exit) and entered an ungrazed one (enter). The samples were collected at 30-pace intervals in an “x” pattern across each rectangular, 0.5-ha plot. The five samples were composited and oven dried at 55ºC for 48 h. Resulting DM values were extrapolated to estimations of kilograms of available DM per hectare. Forage sampling dates (days) are shown in Table 2.5.

Figure 2.3. Metal frame used for pasture sampling.

Table 2.5. Forage sampling dates (days).

Periods	Year 1	Year 2
1	Jul 18 to Jul 30	Jul 17 to Jul 24
2	Jul 30 to Aug 09	Jul 24 to Aug 5
3	Aug 09 to Aug 23	Aug 14 to Aug 21
4	Aug 23 to Sep 10	Aug 21 to Sep 02
5	Sep 10 to Sep 24	Sep 02 to Sep 12

Forage “grab” samples were taken on the same dates (days) as estimation of available DM samples were taken (Table 2.4). Approximately 100 g of forage was hand clipped at 20-pace intervals as an “x” pattern was walked through each “exit” and “enter” plot. These samples were physically separated into alfalfa and orchardgrass components and oven-dried at 55ºC for 48 h. After drying, samples were ground through a Wiley Mill (1-mm screen) and stored at room temperature in a dry environment until analyzed. Near infrared spectrometry (NIRS) was used to determine DM, NDF, ADF, and CP. Twenty percent of the forage grab samples were analyzed for DM (AOAC, 1990), NDF (AOAC, 1990), ADF (AOAC, 1990), and CP (AOAC, 1990) were used to validate numbers.

Statistical Analysis

Lamb data were analyzed using GLM procedure of SAS (2003). Analyses were conducted by period as completely randomized designs with factors, treatment (S = supplemented; US = unsupplemented) and breed (PP = Polypay; WD = White Dorper). The group of lambs grazing a plot during a period (enter vs. exit) was considered to be the experimental unit and years provided the replication. Data were not analyzed to account for the repeated effect of period (plot) because differences at each specific period (plot) were of intrinsic interest. FEC were assumed to not be normally distributed; thus, they were log transformed (ln FEC + 50) prior to statistical analysis. Results were interpreted to be statistically significant at $P < 0.10$.

Forage data were analyzed in a similar manner, although it was recognized that agronomic characteristics of the plots changed across time. As with lamb data, differences at each specific period, regardless of plot, were of intrinsic interest. Preliminary analyses, assuming repeated measures models (repeated effect of period/plot) were conducted for lamb, FEC, and forage data using PROC GLIMMIX (SAS, 2003). Overall, results were compatible to those obtained using PROC GLM. It was determined that analysis by period better answered the questions of interest in this study; therefore, it is those results that are presented. Results were interpreted to be statistically significant at $P < 0.10$.

Chapter IV

Results and Discussion

Lamb Weights and Gains

Lambs were individually weighed at an average of 60 days and removed from ewes on the same day. Poe et al. (1969) showed that early weaning at 60 days of age required a 2-week “adjustment period” before lambs could be expected return to their pre-weaning maximum performance. These researchers recommended that early-weaned lambs remain in their same pre-weaning environment for 2 weeks to prevent as much “weaning stress” as possible. The current study allowed lambs to remain in their pre-weaning environments for 7-day (year 1) and 11-day (year 2) adjustment period. During this weaning adjustment phase, lambs were fed, as one group, increasing amounts of the supplement shown in Table 1.2. On allotment day, lambs were separated into supplemented Polypay (S-PP), supplemented White Dorper (S-WD), unsupplemented Polypay (US-PP), and unsupplemented White Dorper (US-WD) groups , transported to their respective, assigned pasture, and fed an average of 0.48 kg/hd in Year 1 and 0.75 kg/hd in Year 2 (Table 3.1 and 3.2).

Table 3.1. Supplemented concentrate intake (kg·head^{-1}·d^{-1}) and percent of initial body weight of Polypay and White Dorper lambs from weaning through adjustment to first weigh date (Year 1).

Breed[a]	PP		WD	
Supplementation[b]	S	US	S	US
Date				
Jun 20 (Initial)	---------------------------------0.48[c]--			
Jun 21	0.37 (1.6)[d]	0.37 (1.6)[d]	0.36 (1.6)[d]	0.36 (1.6)[d]
Jun 22	0.37 (1.6)	0.31 (1.3)	0.36 (1.6)	0.33 (1.5)
Jun 23	0.37 (1.6)	0.27 (1.1)	0.36 (1.6)	0.28 (1.3)
Jun 24	0.37 (1.6)	0.23 (1.0)	0.36 (1.6)	0.23 (1.1)
Jun 25	0.37 (1.6)	0.18 (0.8)	0.36 (1.6)	0.19 (0.9)
Jun 26	0.41 (1.7)	0.14 (0.6)	0.41 (1.8)	0.14 (0.6)
Jun 27	0.41 (1.7)	0.09 (0.4)	0.41 (1.8)	0.10 (0.4)
Jun 28	0.41 (1.7)	-	0.41 (1.8)	-
Jun 29	0.41 (1.7)	-	0.41 (1.8)	-
Jun 30	0.41 (1.7)	-	0.41 (1.8)	-
Jul 1	0.45 (1.9)	-	0.41 (1.8)	-
Jul 2	0.45 (1.9)	-	0.45 (2.0)	-
Jul 3	0.45 (1.9)	-	0.45 (2.0)	-
Initial lamb wt., kg. Jun 20	23.8	23.5	22.1	22.0

[a] PP = Polypay; WD = White Dorper.

[b] S = supplemented; US = unsupplemented.

[c] Concentrate consumed by all lambs on initial weigh date (June 20) prior to allottement to treatment.

[d] Values in parentheses are supplement intakes expressed as a percentage of initial weight taken on June 20.

Table 3.2. Supplemented concentrate intake (kg·head^{-1}·d^{-1}) and percent of initial body weight of Polypay and White Dorper lambs from weaning through adjustment to first weigh date (Year 2).

Breed[a]	PP		WD	
Supplementation[b]	S	US	S	US
Date				
Jun 30 (Initial)	0.75[c]			
Jul 1	0.44 (1.5)[d]	0.36 (1.3)[d]	0.36 (1.5)[d]	0.36 (1.5)[d]
Jul 2	0.44 (1.5)	0.36 (1.3)	0.36 (1.5)	0.29 (1.2)
Jul 3	0.49 (1.7)	0.36 (1.3)	0.40 (1.6)	0.29 (1.2)
Jul 4	0.49 (1.7)	0.32 (1.1)	0.40 (1.6)	0.28 (1.2)
Jul 5	0.51 (1.8)	0.27 (1.0)	0.41 (1.7)	0.23 (1.0)
Jul 6	0.51 (1.8)	0.25 (0.9)	0.41 (1.7)	0.21 (.09)
Jul 7	0.53 (1.8)	0.22 (0.8)	0.44 (1.8)	0.18 (0.7)
Jul 8	0.53 (1.8)	0.16 (0.6)	0.44 (1.8)	0.14 (0.6)
Jul 9	0.55 (1.9)	0.11 (0.4)	0.45 (1.8)	0.09 (0.4)
Jul 10	0.55 (1.9)	0.05 (0.2)	0.45 (1.8)	0.05 (0.2)
Jul 11	0.58 (2.0)	-	0.48 (2.0)	-
Jul 12	0.58 (2.0)	-	0.48 (2.0)	-
Jul 13	0.58 (2.0)	-	0.48 (2.0)	-
Jul 14	0.58 (2.0)	-	0.48 (2.0)	-
Initial lamb wt., kg. Jun 30	29.1	28.2	24.5	24.1

[a] PP = Polypay; WD = White Dorper.

[b] S = supplemented; US = unsupplemented.

[c] Concentrate consumed by all lambs on initial weigh date (June 30) prior to allotment to treatment.

[d] Values in parentheses are supplement intake (kg/lamb/d) expressed as a percentage of initial weight taken on June 30.

Therefore, S-PP and S-WD were fed increasing amounts of supplement until they consumed their target intake of 2% BW daily (based on initial lamb weights taken on June 20 in Year 1 and June 30 in Year 2). Concurrently, US-PP and US-WD lambs were fed decreasing amounts of supplement until no daily supplement was offered after June 27 in Year 1 and July 10 in Year 2.

Weights of S-PP, US-PP, S-WD, and US-WD lambs taken at 2-week intervals are shown in Table 3.3.

Table 3.3. Least squares means for weights (kg/head) of Polypay and White Dorper lambs grazing alfalfa/orchardgrass pasture and supplemented with a concentrate mix at 2% body weight daily.

Breed[a]	PP		WD			
Supplementation[b]	S	US	S	US	SEM[c]	P-value
Weigh Day						
1	25.0	24.3	22.2	22.2	0.97	0.35
2	28.8	27.2	25.6	24.9	1.00	0.35
3	32.6	29.8	29.1	27.7	1.10	0.10
4	35.9	31.2	32.3	29.6	1.15	0.03
5	40.7	34.2	36.0	31.6	1.26	0.04
6	44.5	37.3	39.9	34.9	1.33	0.05
7	47.5	38.2	42.4	35.6	1.37	0.03

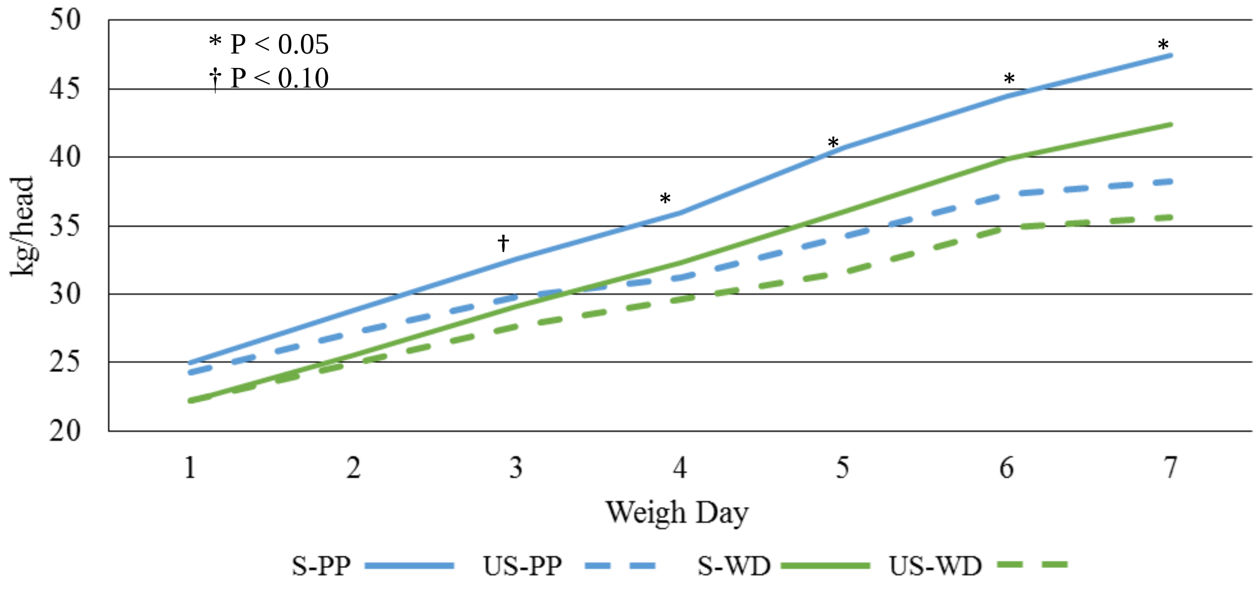
[a] PP = Polypay; WD = White Dorper.

[b] S = supplemented; US = unsupplemented.

[c] Standard error of the mean.

Weigh date (day) 1 corresponded to June 20 in Year 1 and June 30 in Year 2. Other dates (days) are shown in Table 2.2. Weights were not different initially or 2-weeks later. Initial significance ($P < 0.10$) was found on day 3. Significant interactions between breed and supplementation were found thereafter on days 4, 5, 6, and 7. The dates of Table 3.3 are graphically illustrated in Figure 3.1.

Figure 3.1. Effect of supplementation on weights of Polypay vs. White Dorper lambs.



Both groups of PP lambs weighed more than WD groups through weigh date 3. Thereafter, the S-WD lambs weighed more than the US-PP. The S-PP lambs continued to weigh the most and the US-WD weighed the least through the end of the study (day 7).

Least squares gain means for lamb breed x supplementation are presented in Table 3.4.

Table 3.4. Least squares mean for gains (kg·head^{-1}·period^{-1}) of Polypay and White Dorper lambs grazing alfalfa/orchardgras pasture and supplemented with a concentrate mix at 2% body weight daily.

Breed[a]	PP		WD			
Supplementation[b]	S	US	S	US	SEM[c]	P-value
Weigh Day						
1	3.7	3.0	3.5	2.7	0.36	0.98
2	3.9	2.5	3.5	2.9	0.36	0.02
3	3.3	1.5	3.2	1.9	0.37	0.08
4	4.8	2.8	3.7	2.0	0.33	0.52
5	4.4	3.5	4.1	3.5	0.70	0.62
6	3.6	1.0	3.1	1.0	0.54	0.07
Overall	**22.7**	**14.1**	**20.8**	**13.9**	0.36	**0.01**

[a] PP = Polypay; WD = White Dorper.
[b] S = supplemented; US = unsupplemented.
[c] Standard error of the mean.

Variability between weigh periods prevented finding a consistent significance among weigh periods. However, an interaction ($P < 0.01$) was found for total gains that encompassed the entire grazing seasons of two years. In general, Polypay lambs gained more than the White Dorpers and supplemented lambs gained more than unsupplemented, but the response of Polypays and White Dorpers to supplementation was not of the same order; thus, the interaction ($P < 0.01$) for overage gain (Table 3.4).

Polypay lambs weighed more ($P < 0.01$) initially than White Dorpers (Table 3.5). They were also heavier at weaning, which was seven (Year 1) and 11 (Year 2) days before initial weights taken on June 20 (Year 1) and June 30 (Year 2).

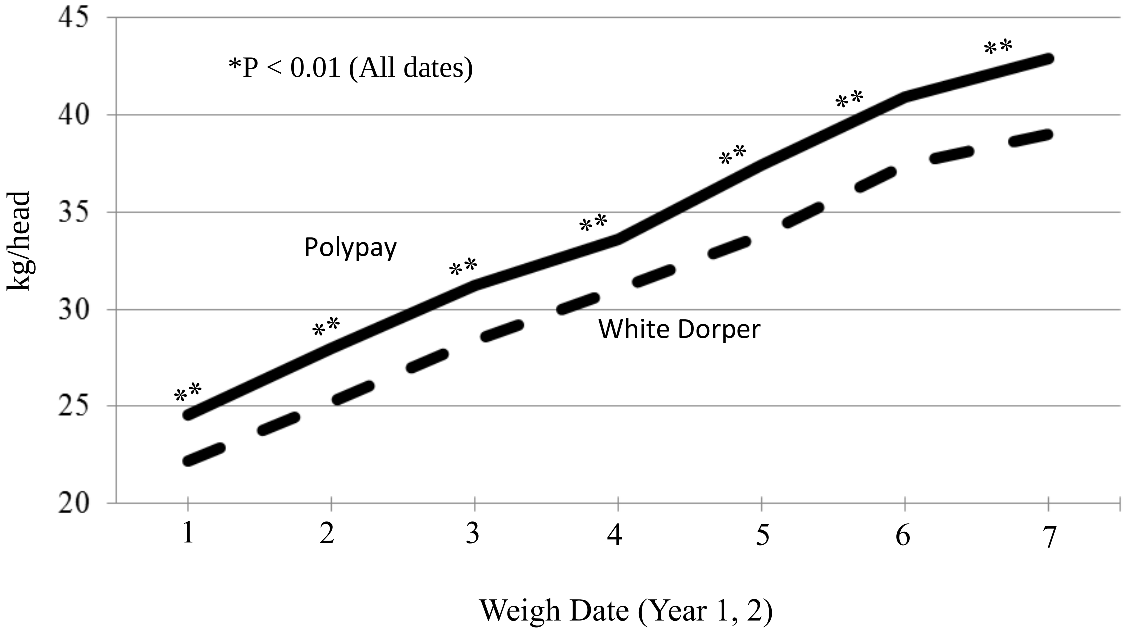
Table 3.5. Least squares means for breed effect on weights (kg/head) of lambs grazing alfalfa/orchardgrass pasture.

	Breed[a]			
	PP	WD	SEM[b]	P-value
Weigh Day				
1	24.6	22.2	0.74	0.01
2	28.0	25.2	0.78	0.01
3	31.2	28.4	0.86	0.01
4	33.6	31.0	0.89	0.01
5	37.4	33.8	0.99	0.01
6	40.9	37.4	1.03	0.01
7	42.9	39.0	1.07	0.01

[a] PP = Polypay; WD = White Dorper.
[b] Standard error of the mean.

The weight difference ($P < 0.01$) were apparent on every weigh day and ranged from 8.5 to11.1% in favor of the Polypays (Figure 3.2).

Figure 3.2. Weights of Polypay and White Dorper lambs grazing alfalfa/orchardgrass pasture.



Aaron et al. (2005) found Polypays weigh 9.8% more than White Dorpers at the end of a summer grazing season (55.8 vs. 50.8 kg/hd). This research, as well as later work (Aaron et al., 2008), reported the 10 to 11% heavier weaning weights of Polypays were maintained throughout the grazing seasons and until slaughter (harvest). These results also agree with SID (2002) who stated that Polypays have a larger fram size, heavier mature weights, and lambs should be harvested at heavier weights than White Dorpers.

Table 3.6 shows that Polypay lambs gained more than White Dorpers during periods 1

(P < 0.08) and 4 (P < 0.01). Gain differences in other periods were nonsignificant. However, overall gains favored (P < 0.01) the Polypays (18.4 vs. 17.4 kg/hd).

Table 3.6. Least squares means for gains (kg·head^{-1}·period^{-1}) of Polypay and White Dorper lambs grazing alfalfa/orchardgrass pasture.

	Breed[a]			
	PP	WD	SEM[b]	P-value
Weigh Period				
1	3.4	3.1	0.28	0.08
2	3.2	3.2	0.28	0.79
3	2.4	2.6	0.29	0.23
4	3.8	2.9	0.26	0.01
5	3.9	3.8	0.54	0.75
6	2.3	2.1	0.25	0.20
Overall	**18.4**	**17.4**	**0.61**	**0.01**

[a] PP = Polypay; WD = White Dorper.
[b] Standard error of the mean.

These data agree with Aaron et al. (2009), who completed a “grading up” experiment and found differences between daily gains of purebred Polypays and graded up White Dorpers increased as the percentage of White Dorper genetics increased to purebreds. These data are in contrast with Thomas (2008) conclusion that post-weaning average daily gains of both breeds are equal at approximately 0.25 kg/hd. While period gains were different only during periods 1 ($P < 0.08$) and 4 ($P < 0.01$), the overall average daily gains of 0.21 for Polypays and 0.20 kg/hd for White Doreprs were different ($P < 0.01$). Therefore, the 8 to 10% weight changes (Table 3.5) may appear to be of the same nonsignificant magnitude, the more precise overall gain (Table 3.6) shows that Polpays gain at a fast rate than White Dorpers when lambs of both breeds graze alfalfa/orchardgrass pasture for 80 (Year 1) and 85 (Year 2) days.

Weights of supplemented and unsupplemented lambs are shown in Table 3.7.

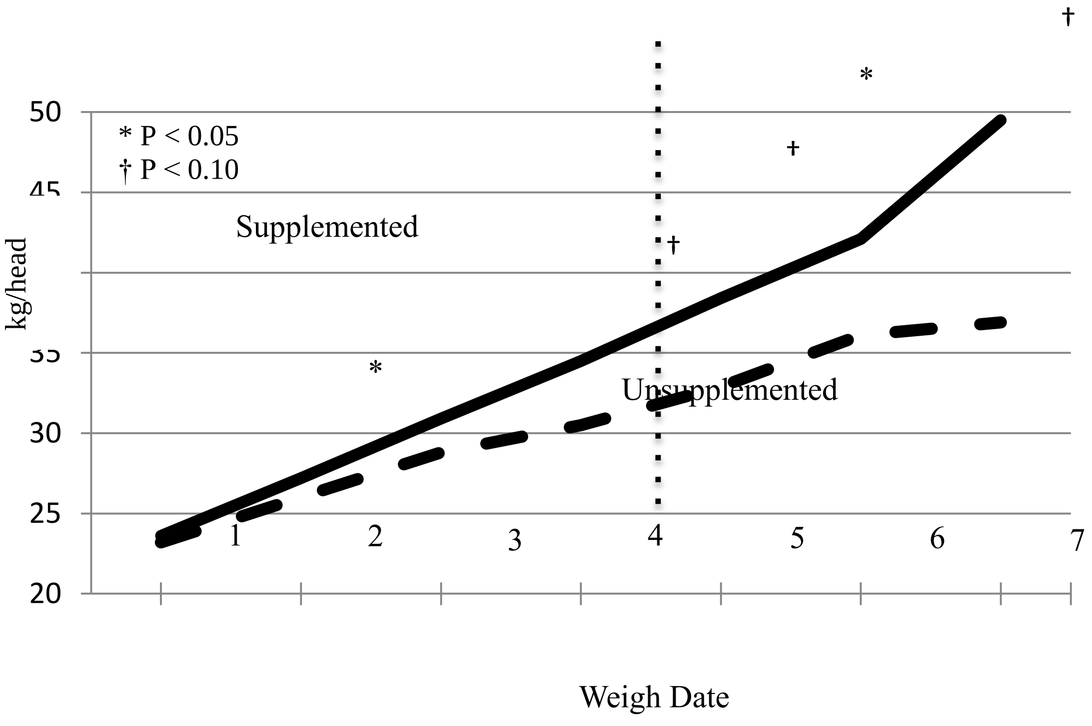
Table 3.7. Least squares means for weights (kg/head) of supplemented (2% body weight of concentrate mix daily) and unsupplemented lambs.

	Supplementation[a]			
	S	US	SEM[b]	P-value
Weigh Date				
1	23.6	23.2	0.37	0.29
2	27.2	26.0	0.19	0.05
3	30.9	28.8	1.26	0.20
4	34.5	30.5	1.00	0.09
5	38.4	32.9	0.98	0.06
6	42.1	36.1	0.56	0.03
7	49.5	36.9	1.33	0.07

[a] S = supplemented; US = unsupplemented.
[b] Standard error of the mean.

Weight day one corresponds to the initial weigh day as lambs were placed in their assigned pastures and supplementation treatments. Supplemented lambs weighed more (P < 0.05) than unsupplemented on weigh day 2 (July 3 in Year 1; July 14 in Year 2). This difference may be a result of the gradual removal of the initial supplementation in the the unuspplemented treatment (Tables 3.1 and 3.2). A comparison of weights shows supplemented lambs weighed 4.6, 7.2, 13.2, 16.7, 16.7, and 34.1% more than unsupplemented on weigh days 2, 3, 4, 5, 6, and 7, respectively. These differences are graphically illustrated in Figure 3.3.

Figure 3.3. Weights of supplemented (2% body weight daily) and unsupplemented lambs grazing alfalfa/orchardgrass pasture.



The fact that supplemented lambs weighed an average of 49.5 kg while unsupplemented lambs weighed only 36.9 kg identifies he need for supplemental energy (Table 2.4) for April-born lambs to reach 45 to 55 kg by the end of a June to late September grazing season when they consume high quialty alfalfa/orchardgrass forge.

Table 3.8 shows enter versus exit values for forage neutral deteregent fiber, acid detergent fiber, and crude protein (dry matter basis). The percentage of forage dry matter as neutral detergent fiber remained fairly constant from period 1 through 5 as both enter and exit acid detergent fiber increased. In general, the curde protein content tended to decrease for bother enter and exit samples after day 2. Crude protein levels ranging form 18.5 to 24.2% of dry matter as lambs entered pastures equates to early to mid bloom alfalfa and early vegatative orchardgrass (NRC, 1984). The neutral detergent vales equate to mid to full bloom alfalfa and late bloom orchardgrass (NRC, 2000). The acid detergent fiber content ranged from 27.9 to 40.1% of dry matter which corresponds to early bloom alfalfa and early vegatative orchardgrass (NRC, 1984).

Table 3. 8. Least squares means of chemical components of alfalfa/orchardgrass forage grazed by April-born lambs as they enter and exit experimental plots.

	Component							
	% DM		NDF[a]		ADF[a]		CP[a]	
	Enter	Exit	Enter	Exit	Enter	Exit	Enter	Exit
Sampling Day								
1	40.8	46.3	58.1	57.0	29.5	28.1	22.0	24.1
2	34.6	41.1	55.7	56.3	27.9	28.5	24.4	24.7
3	29.7	39.6	54.7	54.4	29.1	33.3	23.0	20.0
4	30.3	40.8	58.0	59.2	30.8	37.3	22.2	18.2
5	29.6	44.6	57.9	59.1	37.4	40.1	18.5	17.5

[a] Percent of dry matter.

Based on these analyses and the fact that approximately two-thirds of the available dry matter was provided by alfalfa, these pastures were arbitrarily deemed “high quality” (Appendix tables 1, 2, 3, and 4).

Gains of supplemented lambs were greater in periods 1 ($P < 0.10$), 4 ($P < 0.01$), 5 ($P < 0.03$), 6 ($P < 0.01$), and overall ($P < 0.05$) than unsupplemented. Karnezos et al. (1994) found that lambs supplemented with corn (0.75% BW daily) gained faster than unsupplemented when grazing alfalfa pastures. However, Ely et al. (1979) had earlier found that early-weaned lambs grazing spring bluegrass pasture in Kentucky balanced their daily ration at approximately 50% forage and 50% concentrate when they had ad libitum access to an all-concentrate, 13% CP grain mix.

Table 3.9. Least squares means for gains (kg·head^{-1}·period^{-1}) of supplemented and unsupplemented lambs grazing alfalfa/orchardgrass pasture.

	Supplementation[a]			
Weigh Period	S	US	SEM[b]	P-value
1	3.6	2.9	0.21	0.10
2	3.7	2.7	1.10	0.35
3	3.3	1.7	2.23	0.42
4	4.3	2.5	0.05	0.01
5	4.2	3.5	0.06	0.03
6	3.4	1.0	0.04	0.01
Overall	**21.8**	**14.0**	**1.14**	**0.05**

[a] S = supplemented; US = unsupplemented.
[b] Standard error of the mean.

The dry requirements for growing/finishing lambs is 4% BW daily (SID, 2002). Therefore, supplementing alfalfa/orchardgrass pasture with 2% BW concentrate mix daily is near optimum for production of lambs slaughtered (harvested) between 45 and 55 kg at the end of the grazing season. Figure 3.3 shows supplemented lambs weighed 49.5 kg while unsupplemented lambs weighed on 36.9 kg. These data support the conclusion of Karnezos et al. (1994) and Ely et al. (1979) that supplemental energy is required to optimally produce 45 to 55 kg lambs from high quality spring/summer pasture of bluegrass or alfalfa/orchardgrass pasture.

Lamb Fecal Egg Counts

The indicators of *H. contortus* infestation in this study were daily visual observations (grazing activity, presence of bottle jaw) and fecal egg counts (FEC). Lambs were dewormed periodically as shown in Figures 2.1 and 2.2. Even though lambs were rotated through experimental pastures, they still had to be dewormed periodically. This management strategy agree with Vanimisetti et al. (2004), who concluded that FEC vary during the year. The *H. contortus* prefer warm temperatures and moist environments (O'Connor et al., 2006). Table 3.10 shows the log-transformed FEC of Polypay and White Dorper supplemented and unsupplemented lambs from collection day 3 (July 17 in Year 1; July 28 in Year 2) through 7 (September 11 in Year 1; September 22 in Year 2).

Table 3.10. Least squares means for log-transformed fecal egg counts of Polypay and White Dorper lambs grazing alfalfa/orchardgrass pasture and supplemented with a concentrate mix at 2% body weight daily.

Breed[a]	PP		WD			
Supplementation[b]	S	US	S	US	SEM[c]	P-value
Collection Day[d]						
1	-	-	-	-	-	-
2	-	-	-	-	-	-
3	3.04	2.92	2.51	2.41	0.13	0.84
4	2.70	2.61	2.43	2.34	0.10	0.91
5	2.73	2.80	2.35	2.56	0.12	0.20
6	2.80	2.24	2.38	2.05	0.12	0.03
7	2.67	2.93	2.12	2.37	0.14	0.93

[a] PP = Polypay; WD = White Dorper.
[b] S = supplemented; US = unsupplemented.
[c] Standard error of the mean.
[d] Fecal samples were not collected until the third collection day (Jul 17, Jul 28).

Fecal samples were not collected on days 1 or 2 because lambs were dewormed immediately prior to placing in their respective pastures (Figure 2.1 and 2.2). They were also so small (weight) on collection days 1 and 2 that risk of injury from fecal sampling outweighed the benefits that may have been obtained for FEC.

Table 3.11 shows Polypay lambs had higher ($P < 0.01$) FEC than White Dorpers on every collection day.

Table 3.11. Least squares means for log-transformed fecal egg counts of Polypay and White Dorper lambs grazing alfalfa/orchardgrass pasture.

	Breed[a]			
	PP	WD	SEM[b]	P-value
Collection Day[c]				
1	-	-	-	-
2	-	-	-	-
3	2.98	2.46	0.12	0.01
4	2.65	2.38	0.09	0.01
5	2.76	2.46	0.11	0.01
6	2.52	2.21	0.11	0.01
7	2.80	2.25	0.17	0.01

[a] PP = Polypay; WD = White Dorper.
[b] Standard error of the mean.
[c] Fecal samples were not collected until the third collection day (Jul 17, Jul 28).

These data agree with visual observations made throughout the grazing seasons. In contrast to White Dorpers, Polypay lambs were more pale in color (anemic) around the eyes, noses, and rectum. The Polypays were also less aggressive grazers, seem to lose more body conditiohn, and in some cases exhibited more adema (bottle jaw) than the White Dorpers. All of these signs are associated with heavy *H. contortus* infestation (Miller and Horohov, 2006). Numerous research studies (Bradford and Fitzhugh, 1983;

Zajac, 1995; Notter et al., 2003) have shown hair breeds of sheep developed in the Caribbean and West Africa (i.e., tropical climate) are more “resistant” to *H. contortus* than wool breeds. Breeds in this “resistant” category include the St. Croix and Barbados Blackbelly. The Kathadin, a cross between the “resistant” St. Croix and non-resistant British breeds, is also claimed to be “resistant”. The White Dorper is a hair breed developed in South Africa in an arid climate. The data in Table 3.11 agrees with the work of Aaron et al. (2009) that shows this breed is not “resistant” to the stomach worm, but the FEC show it may be more “resistant” than the wooled Polypay breed.

Gibson (1963) and Shaw et al. (1995) found that supplementation with protein is associated with reduced FEC in lambs. They hypothesized that supplemented lambs were able to maintain a stronger immune system, which allows animals to “fight off” or still be able to perform (gain weight) even when a population of stomach worms inhabit the abomasum (resilience). Lambs in this study were provided a relatively dense supplement (Table 2.1).

Results of this supplementation are shown in Table 3.12. Even though P values were significant on every collection day, there was no consistent effect of supplementation on the FEC. The cause of this inconsistency is unclear, but deworming upon need (observation, previous FEC) may have contributed to the variation found amount collection days.

Table 3.12. Least squares means for log-transformed fecal egg counts of supplemented and unsupplemented lambs grazing alfalfa/orchardgrass pasture.

	Supplementation[a]			
	S	US	SEM[b]	P-value
Collection Day[c]				
1	-	-	-	-
2	-	-	-	-
3	2.77	2.66	0.03	0.07
4	2.56	2.47	0.08	0.05
5	2.54	2.68	0.50	0.01
6	2.59	2.15	0.50	0.01
7	2.39	2.63	0.07	0.01

[a] S = supplemented; US = unsupplemented.
[b] Standard error of the mean.

Grazing Strategy

Forage data were analyzed as differences between available DM, NDF, ADF, and CP when Polypay and White Dorper lmabs that were supplemented or unsupplemented entered and exited the 0.53ha plots of alfalfa/orchardgrass. Table 3.13 shows the effect of breed and supplement on the alfalfa DM portion of these differences. Appendix Table 1 and 2 show the estimated availability (kg/ha) of all alfalfa components (DM, NDF, ADF, and CP). Negative values in Table 3.13 indicates there was less available DM when lambs exited a plot than when they entered. Available alfalfa DM difference (exit minus enter) was largest (more negative) for unsupplemented Polypays in periods 1 (-1636 kg/ha) and 2 (-590 kf/ha). The smallest difference was found for unsupplemented Polypays (period 1 = -221; period 2 = 770 kg/ha). The exit/enter differences for unsupplemented White Dorpers were -288 and 219 kg/ha while supplemented White Dorpers had a difference of -289 and 205 kg/ha. The breed x supplementation interaction was significant only for periods 1 ($P < 0.08$) and 2 ($P < 0.09$).

Table 3. 13. Least squares means for exit minus enter available alfalfa dry matter (kg/ha) when Polypay and White Dorper lambs were rotated through alfalfa/orchardgrass pastures and supplemented with a concentrate mix 2% body weight daily.[a]

Breed[b]	PP		WD			
Treatment[c]	S	US	S	US	SEM[d]	P-value
Period						
1	-221	-1636	-289	-288	239.3	0.08
2	770	-590	205	219	305.5	0.09
3	156	-82	21	345	182.5	0.20
4	-524	-150	-143	-164	304.5	0.59
5	36	-140	-188	-479	389.9	0.89

[a] Negative values show less available dry matter per hectare when lambs exited pastures than when they entered.

[b] PP = Polypay; WD =White Dorper.

[c] S = supplemented; US = unsupplemented.

[d] Standard error of the mean.

Similar results were found for NDF: largest exit minus enter differences were found for Polypay lambs that were unsupplemented (Table 3.14) The magnitude of this difference, when compared with groups may indicated these lambs consumed more of the entire alfalfa shoot rather than selectively grazing the leaf portion. Because the majority of NDF is located in the alfalfa stem, the larger negativity of exit/enter difference could mean consumed NDF was more digestible in the rumen which potentially could have stimulated great intake (Collins, 1988). Although breed x supplement interaction was significant only for period 1 ($P < 0.01$) and 2

($P < 0.04$), numerically negative values were also found for periods 3, 4, and 5. In contrast, unsupplemented White Dorpers had positive exit/enter values for periods 2 and 3. Variation in response to supplementation for Polypay and White Dorper prevented finding significant interactions for periods 3, 4, and 5.

Table 3. 14. Least squares means for exit minus enter available alfalfa neutral detergent fiber (kg/ha) when Polypay and White Dorper lambs were rotated through alfalfa/orchardgrass pastures and supplemented with a concentrate mix at 2% body weight daily.[a]

Breed[b]	PP		WD			
Treatment[c]	S	US	S	US	SEM[d]	P-value
Period						
1	-90	-996	-167	-302	48.0	0.01
2	269	-257	144	217	77.3	0.04
3	96	-87	0.42	187	102.6	0.15
4	-317	-07	45	-08	58.3	0.19
5	73	-130	45	-355	63.1	0.34

[a] Negative values show less available dry matter per hectare when lambs exited pastures than when they entered.
[b] PP = Polypay; WD =White Dorper.
[c] S = supplemented; US = unsupplemented.
[d] Standard error of the mean.

Exit minus enter ADF differences (Table 3.15) were not of the same magnitude in period 1 for supplemented and unsupplemented Polypays as they were for supplemented and unsupplemented White Dorpers; thus, the interaction ($P < 0.01$). Differences approached significance in period 2 and became significant ($P < 0.03$) in period 5.

Overall, it is difficult to establish any trend for exit minus enter differences for the alfalfa fiber components (NDF and ADF). It might be theorized that larger differences found early in the grazing season (periods 1 and 2) were a results of the heavier weights of Polypay lambs (Table 3.3) and lager numbers of Polypay lambs per treatement group (Table 2.1). A heavier stocking rate (more lambs per 0.53 ha) with heavier weight lambs could have caused high daily consumption of the fibrous DM components of alfalfa. However, application of this theory was not consistent through periods 3, 4, and 5.

Table 3. 15. Least squares means for exit minus enter available alfalfa acid detergent fiber (kg/ha) when Polypay and White Dorper lambs were rotated through alfalfa/orchardgrass pastures and supplemented with a concentrate mix at 2% body weigh daily.[a]

Breed[b]	PP		WD			
Treatment[c]	S	US	S	US	SEM[d]	P-value
Period						
1	-12	-463	-167	-69	42.2	0.01
2	239	-140	131	148	98.7	0.17
3	73	81	54	214	179.9	0.69
4	46	-42	104	09	158.6	0.99
5	229	115	133	-291	7.1	0.03

[a] Negative values show less available dry matter per hectare when lambs exited pastures than when they entered.
[b] PP = Polypay; WD =White Dorper.
[c] S = supplemented; US = unsupplemented.
[d] Standard error of the mean.

There were no interactions found for alfalfa CP exit minus enter differences (Table 3.16), even though CP composition (percent DM) of the total forage (alfalfa and orchardgrass) decreased from period 1 through 5 (Table 3.8). Even though the percentage decreased from June through September, the level was always above 17.5%. Also there was always an excess of forage DM available from period 1 through 5. Consequently, it was not hypothesized there would be a difference between exit and enter CP availability.

Table 3. 16. Least squares means for exit minus enter available alfalfa crude protein (kg/ha) when Polypay and White Dorper lambs were rotated through alfalfa/orchardgrass pastures and supplemented with 2% body weigh daily.[a]

Breed[b]	PP		WD			
Treatment[c]	S	US	S	US	SEM[d]	P-value
Period						
1	-48	-308	12	-58	92.3	0.43
2	183	-140	156	-20	127.8	0.64
3	-23	-96	22	20	120.7	0.78
4	-232	111	-09	-92	83.9	0.23
5	-60	-147	28	-191	199.3	0.78

[a] Negative values show less available dry matter per hectare when lambs exited pastures than when they entered.

[b] PP = Polypay; WD =White Dorper.

[c] S = supplemented; US = unsupplemented.

[d] Standard error of the mean.

Table 3.17 shows no significant exit minus enter differences for orchardgrass DM. The actual yield of the orchardgrass components (DM, NDF, ADF, and CP) of the alfalfa/orchardgrass pasture are sown in Appendix Tables 3 and 4. No differences were found for any of these components. No exit minus enter differences were found for orchardgrass NDF (Table 3.18), ADF (Table 3.19), or CP (Table 3.20) These results indicate there was always and excess of orchardgrass forage available for consumption. Furthermore, when the available (exit minus enter) alfalfa DM, NDF, ADF, and CP components (Table 3.13, 3.14, 3.15, and 3.16) are compared with the orchardgrass components, it appears the lambs consumed more of the alfalfa forage throughout the grazing season. This finding agrees with Christie (1995) who found that orchardgrass produces heavy growth in April and May, but production and quality are reduced in summer resulting in decreased intake.

Table 3. 17. Least squares means for exit minus enter available orchardgrass dry matter (kg/ha) when Polypay and White Dorper lambs were rotated through alfalfa/orchardgrass pastures and supplemented with a concentrate mix 2% body weight daily.[a]

Breed[b]	PP		WD			
Treatment[c]	S	US	S	US	SEM[d]	P-value
Period						
1	-84	-672	45	-139	188.1	0.41
2	592	114	540	369	151.8	0.37
3	03	450	447	633	225.9	0.59
4	-306	251	114	330	106.7	0.26
5	646	402	97	742	296.8	0.21

[a] Negative values show less available dry matter per hectare when lambs exited pastures than when they entered.

[b] PP = Polypay; WD =White Dorper.

[c] S = supplemented; US = unsupplemented.

[d] Standard error of the mean.

Table 3. 18. Least squares means for exit minus enter available orchardgrass neutral detergent fiber (kg/ha) when Polypay and White Dorper lambs were rotated through alfalfa/orchardgrass pastures and supplemented with a concentrate mix at 2% body weight daily.[a]

Breed[b]	PP		WD			
Treatment[c]	S	US	S	US	SEM[d]	P-value
Period						
1	-70	-453	33	-185	215.3	0.74
2	376	239	336	231	128.5	0.91
3	33	202	261	424	158.2	0.99
4	-262	161	100	220	87.4	0.23
5	432	480	250	512	436.8	0.83

[a] Negative values show less available dry matter per hectare when lambs exited pastures than when they entered.

[b] PP = Polypay; WD =White Dorper.

[c] S = supplemented; US = unsupplemented.

[d] Standard error of the mean.

Table 3. 19. Least squares means for exit minus enter available orchardgrass acid detergent fiber (kg/ha) when Polypay and White Dorper lambs were rotated through alfalfa/orchardgrass pastures and supplemented with a concentrate mix at 2% body weigh daily.[a]

Breed[b]	PP		WD			
Treatment[c]	S	US	S	US	SEM[d]	P-value
Period						
1	-45	-245	18	-106	126.3	0.79
2	188	25	175	108	56.0	0.44
3	16	93	144	220	85.1	0.98
4	-160	89	67	122	41.2	0.15
5	246	121	150	282	190.9	0.57

[a] Negative values show less available dry matter per hectare when lambs exited pastures than when they entered.
[b] PP = Polypay; WD =White Dorper.
[c] S = supplemented; US = unsupplemented.
[d] Standard error of the mean.

Table 3. 20. Least squares means for exit minus enter available orchardgrass crude protein (kg/ha) when Polypay and White Dorper lambs were rotated through alfalfa/orchardgrass pastures and supplemented with 2% body weigh daily.[a]

Breed[b]	PP		WD			
Treatment[c]	S	US	S	US	SEM[d]	P-value
Period						
1	-03	-54	21	23	24.9	0.40
2	102	28	105	76	35.8	0.56
3	-42	86	58	131	43.6	0.61
4	07	16	-21	44	26.8	0.41
5	105	97	46	145	84.6	0.60

[a] Negative values show less available dry matter per hectare when lambs exited pastures than when they entered.
[b] PP = Polypay; WD =White Dorper.
[c] S = supplemented; US = unsupplemented.
[d] Standard error of the mean.

Chapter V

Summary and Conclusion

Based on the data collected over the two years of this experiment, the following conclusions of Polypay and White Dorper lambs grazing alfalfa/orchardgrass pastures it can be concluded that there is a significant interaction between breed and supplementation on weights from weigh date to weigh date. With S-PP weighing significantly more and responded to supplement better than S-WD. On the other hand, when comparing gains, supplemented lambs, both Polypay and White Dorper, gained significantly more weight than unsupplemented lambs, both Polypay and White Dorper. Because significant gains were not consistently found, it was determined that supplemented lambs (2% BW) produced more gain than unsupplemented lambs, across breed. In addition, Polypay lambs gained significantly more weight than White Doper lambs, across supplementation. There was only collection date where significant interaction was detected. On this collection date, S-PP had a significantly higher log-transformed FEC (2.80) than the other groups ($P < 0.03$). It was also determined there were consistent significant differences between breeds and log-FEC with Polypay lambs having greater log-FEC throughout the grazing season. In addition, significance was detected at every collection date concerning supplementation. However, this data was not consistent, so no conclusions could be made concerning differences between supplementation vs. unsupplemented lambs.

It was discovered the US-PP had a greater change in total alfalfa DM from exit to enter at the beginning of the grazing season. Early in the grazing season (Period 1 and 2) unsupplemented lambs had a greater disappearance in NDF and ADF of alfalfa DM. This could lead to the assumption that unsupplemented lambs consumed whole shoot alfalfa, including stems, where the NDF and ADF are primarily located. Throughout the entire grazing season no significant differences were detected concerning CP of alfalfa DM or orchardgrass DM. This indicates that high quality forage was available to all groups throughout the grazing season. In addition, no significance was found for orchardgrass DM or any of its quality components (NDF and ADF) throughout the season. Since no differences were found in orchardgrass, it is assumed that lambs were selecting alfalfa over orchardgrass. From these summaries, it can be concluded that April born Polypay and White Dorper lambs grazing alfalfa/orchardgrass pasture require supplementation (2% BW) for maximum postweaning growth.

Appendix

Appendix Table 1. Alfalfa dry matter, neutral detergent fiber, acid detergent fiber, and crude protein when Polypay and White Dorper lambs entered and exited alfalfa/orchardgrass pastures (kg/ha).

Breed[a]	PP		WD			
Period	Enter	Exit	Enter	Exit	SEM[b]	P-value
	Dry Matter					
1	1,643	963	1,444	1,156	179	0.30
2	977	1,067	986	1,198	171	0.76
3	1,299	1,336	1,054	1,237	136	0.60
4	1,313	1,162	1,211	1,058	231	1.00
5	1,305	1,253	1,498	1,165	173	0.55
	Neutral detergent fiber					
1	834	509	825	590	95	0.68
2	513	519	398	576	65	0.31
3	679	684	511	605	79	0.60
4	721	633	581	588	87	0.58
5	708	724	686	588	87	0.48
	Acid detergent fiber					
1	409	241	392	274	64	0.71
2	233	283	241	352	62	0.66
3	412	489	328	462	118	0.80
4	393	454	426	547	144	0.82
5	483	731	467	679	213	0.91
	Crude Protein					
1	418	246	348	325	56	0.21
2	267	289	295	336	75	0.90
3	312	252	223	244	56	0.45
4	263	238	241	167	43	0.60
5	256	191	303	232	44	0.96

[a] PP = Polypay; WD = White Dorper.

[b] Standard error of the mean.

Appendix Table 2. Alfalfa dry matter, neutral detergent fiber, acid detergent fiber, and crude protein when supplemented and unsupplemented lambs entered and exited alfalfa/orchardgrass pasture (kg/ha).

Supplementation[a]	Dry Matter					
	S		US			
Period	Enter	Exit	Enter	Exit	SEM[b]	P-value
1	1,353	1,098	1,735	1,020	179	0.23
2	748	1,235	1,215	1,029	171	0.11
3	1,347	1,435	1,006	1,138	136	0.87
4	1,240	1,020	1,284	1,199	231	0.70
5	1,236	1,160	1,567	1,258	233	0.62
	Neutral detergent fiber					
1	672	544	987	555	95	0.18
2	329	534	581	561	65	0.19
3	675	723	515	566	79	0.99
4	679	652	624	569	87	0.87
5	595	674	799	637	86	0.17
	Acid detergent fiber					
1	347	258	453	257	64	0.44
2	176	333	298	302	62	0.30
3	464	527	276	423	118	0.71
4	399	511	419	490	143	0.88
5	476	831	474	579	211	0.50
	Crude Protein					
1	338	320	428	251	56	0.18
2	212	354	351	271	75	0.17
3	258	257	276	238	56	0.72
4	270	192	234	213	43	0.55
5	213	227	347	195	44	0.13

[a] S = supplemented; US = unsupplemented.

[b] Standard error of the mean.

Appendix Table 3. Orchardgrass dry matter, neutral detergent fiber, acid detergent fiber, and crude protein when Polypay and White Dorper lambs entered and exited alfalfa/orchardgrass pastures (kg/ha).

Breed[a]	PP		WD			
Period	Enter	Exit	Enter	Exit	SEM	p-value
	Dry matter					
1	648	472	577	530	173	0.69
2	411	764	411	865	118	0.66
3	544	771	545	1084	130	0.23
4	747	830	762	984	248	0.76
5	395	919	684	1104	199	0.80
	Neutral detergent fiber					
1	522	296	360	377	102	0.23
2	236	543	267	550	68	0.85
3	363	581	330	673	103	0.52
4	448	549	462	622	147	0.83
5	248	609	455	746	221	0.84
	Acid detergent fiber					
1	272	143	179	175	57	0.23
2	114	220	145	286	40	0.66
3	177	253	160	343	49	0.26
4	211	240	232	326	58	0.56
5	128	253	244	422	109	0.77
	Crude Protein					
1	122	103	97	140	18	0.17
2	95	160	78	168	32	0.68
3	140	149	116	211	31	0.15
4	155	213	168	179	49	0.62
5	80	147	119	207	51	0.80

[a] PP = Polypay; WD = White Dorper.

[b] Standard error of the mean.

Appendix Table 4. Orchargrass dry matter, neutral detergent, acid detergent fiber, and crude protein when supplemented and unsupplemented lambs entered and exited alfalfa/orchardgrass pasture (kg/ha).

	Dry Matter					
Supplementation[a]	S		US			
Period	Enter	Exit	Enter	Exit	SEM	P-value
1	507	487	718	514	173	0.58
2	437	1003	385	626	118	0.18
3	677	902	412	954	130	0.22
4	803	926	706	888	248	0.90
5	654	1026	425	997	199	0.63
	Neutral detergent fiber					
1	325	306	557	367	101	0.40
2	269	625	234	469	68	0.37
3	428	574	256	679	103	0.19
4	500	570	410	600	147	0.65
5	416	573	286	782	221	0.36
	Acid detergent fiber					
1	170	157	281	162	56	0.32
2	138	319	121	187	40	0.16
3	216	296	121	299	49	0.30
4	247	271	195	295	59	0.48
5	223	324	149	351	108	0.59
	Crude Protein					
1	91	100	128	143	18	0.89
2	91	194	82	134	32	0.41
3	149	157	107	203	31	0.14
4	161	188	161	204	47	0.86
5	118	157	81	202	51	0.32

[a] S = supplemented; US = unsupplemented.

[b] Standard error of the mean.

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Vita

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