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Factors Influencing Grass Utilization Patterns And Growth Performance In Outdoor Swine

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FACTORS INFLUENCING GRASS UTILIZATION PATTERNS AND GROWTH PERFORMANCE IN OUTDOOR SWINE

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BIOGRAPHICAL SKETCH

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LIST OF ABBREVIATIONS

B	Berkshire
BG	Bermuda grass
CAFO	Concentrated Animal Feeding Operations
CEFS	Center for Environmental Farming Systems
CFU	Colony Forming Units
FIRE	Feed Intake and Recording Equipment
GIS	Geographic Information System
GPS	Global Positioning System
IBS	International Boar Semen
LB	Large Black
MAR	Multiple Antibiotic Resistance
MQ	Max Q Fescue
MS	Multispecies grasses; Redtop, Kentucky Bluegrass, Kentucky 31 Tall Fescue
RFID	Radio Frequency Identification
RTLS	Real Time Location System
SAS	Statistical Analysis Systems
T	Tamworth
TF	Kentucky 31 Tall Fescue
Y	Yorkshire

ABSTRACT

Ireland, Sequoia A. FACTORS INFLUENCING GRASS UTILIZATION PATTERNS AND GROWTH PERFORMANCE IN OUTDOOR SWINE. **(Advisor: Ralph Noble),** North Carolina Agricultural and Technical State University.

Six gestating Yorkshire sows were evaluated in a pasture grazing system for a spring, summer to fall, and winter trial. The pasture was divided into four different grass sections containing; 1) endophyte- infected Kentucky 31 Tall Fescue, 2) non-toxic endophyte infected Max Q Fescue, 3) multispecies grass including Redtop, Kentucky Bluegrass, and Kentucky 31 Fescue, and 4) common Bermudagrass. Each sow was assigned a global positioning system (GPS) unit by Telespial Systems, which notifies researchers of animal position at all times. The attained data was then used to determine how often different areas of the pasture were frequented. Grass score assessment was conducted after the sows were removed from pasture to determine associations between the percentages of time spent in the grass section and grass integrity.

Growth performance was evaluated from offspring selected from the six Yorkshire sows in the winter trial. They consisted of 40 Yorkshire crosses; Yorkshire x Yorkshire, Large Black x Yorkshire, and Berkshire x Yorkshire that were finished in a hoop structure. An automated Feed Intake and Recording Equipment (FIRE) were used to supply feed, weigh each pig, and measure feed intake. Growth performance was evaluated by measuring average daily gain (ADG) and feed intake (FI). Feed efficiency (FE) was calculated based on feed intake and average daily gain.

Grass type did not influence frequency of grass section use by sow. Based on collected data, time spent in the individual grass sections was Bermuda grass =13.95%, Multispecies = 13.87%, Max Q =18.94%, and Kentucky 31 Tall Fescue = 15.76%. Grass integrity data showed a higher frequency of grass score values of two (37.92%) and three (38.57%). Overall the sows spent the greatest percentage of time in the grass areas (62.52%) compared to the platform (37.46%). Growth performance of sows' offspring was not impacted by breed of sire; 1) Yorkshire cross, FI = 1.5 kg, ADG = 1.5 kg, FE = 1.0, 2) Berkshire cross, FI =1.4 kg, ADG = 1.5 kg, FE = 0.97, 3) Tamworth cross, FI = 1.5 kg, ADG = 1.5 kg, FE = 1.0. Gender did influence feed efficiency, with gilts having better FE to attain similar ADG values as males; 1) Male, FI =1.6 kg, ADG =1.5 kg, FE = 1.03, 2) Female, FI =1.4 kg, ADG =1.4 kg, FE =0.9.

CHAPTER 1

INTRODUCTION

The use of antibiotics in food animals worldwide is an issue of growing concern, spurred by the evolution of an increase in resistant bacteria (Chapin et al., 2004; Wegener, 2003). Unfortunately the effects of this phenomenon are impacting human populations at an alarming rate (Chapin et al., 2004; Wegener, 2003). Farmers use antibiotics in food animals for prophylactic and therapeutic use (Wegener, 2003). Prophylactic refers to the use of antibiotics prior to animals displaying clinical symptoms; administering drugs to prevent the onset of disease or illness. Whereas, therapeutic treatment is when a sick animal is administered medication. Antibiotics are also used as growth promoters to decrease the time needed to reach market weight. The use of these drugs in animals has been reported to increase antibiotic resistance in humans (Chapin et al., 2004). When an animal is exposed to a drug, and then consumed by a human, there is a certain amount of drug residue left in the meat (Chapin et al., 2004). Humans, upon consumption, subject their bodies' natural defense system to these residues, and when they need it the most their body cannot fight off the bacteria even with the assistance of drugs. For this reason, there are current guidelines which limit the use of certain classes of drugs in food animals (Chapin et al., 2004; Predicala et al., 2002; Wegener, 2003). Meeting these guidelines is required to implement sustainable livestock production systems.

Outdoor swine production can be a sustainable, low cost alternative to confinement swine management. Substitutes for confinement stalls include; hooped shelters, deep-bedded systems, and pasture systems (Gegner, 1999). These schemes can be used individually or combined. Advantages to outdoor schemes include a feeding system that utilizes a higher rate of forages and by-products, and low cost housing. Outdoor systems also benefit the work environment and surrounding communities, as well as being better suited for the natural behavior of swine (Gegner, 1999; Honeyman, 1991; SARE Outreach, 2001). Some consumers are even willing to pay $1 more per pound for meats that they know were raised in humane, safe, organic, earth friendly, and antibiotic free environments (Gegner, 1999). Implementation of these alternative systems improves air quality for workers, surrounding communities, environment and the animals (SARE Outreach, 2001). The outdoor system is suitable for pigs from farrow to finish.

The pasture system is ideal for gestating sows in a farrowing system. Pigs are produced on designated acreage which is surrounded by a fence. In preparation for farrowing, a hog producer usually supplies a hut made of wood, metal, or plastic and bedded with straw or wood shavings to assist with temperature regulation by the piglets. A common type of farrowing hut is the English style hut, which has a large arc opening to allow the sow and piglets easy entrance and exit. It has been reported that swine had fewer incidences of respiratory diseases, rhinitis, and foot and leg problems (Cramer, 1990; Gentry et al., 2001). Texas Tech University's Sustainable Pork Program has studied outdoor pig production since 1993. Since its inception, they have developed a prototype for pasture grazing (SARE Outreach, 2001). This model allots three sows per acre, in a 100 acre system for a 300 sow unit. By dividing the model into breeding paddock, gestation paddock, and farrowing paddock, researchers were able to achieve the same tasks as a confinement model in an environmentally friendly atmosphere. Boars and sows are housed together for breeding, and then separated during gestation. Sows are assigned separate space to farrow. Researchers at Texas Tech University reported that there is a cost difference of $7.80 to raise an outdoor pig at $23.20, versus in confinement at a cost of $31, with an overall net profit of $10.39 for pigs raised outdoor (SARE Outreach, 2001). Another advantage to this pasture system is that the majority of costs for raising hogs are associated with feed, and this cost can be offset by allowing sows to graze naturally outdoors on the land.

Pasture hogs studies over the years have reduce waste management concerns. Outdoor pigs disperse the manure on pasture, thereby reducing need for man power to monitor the lagoon and flushing tanks that would normally be found in a confinement facility. Allowing pigs to naturally distribute manure minimizes pollution hazards, parasites, and disease transfer (Gegner, 1999). Traditional views of the pasture system consider it to be an intense labor, minimal cost, and low management system (Honeyman, 1991). Outdoor pig production can be a huge environmental concern when not managed correctly. Ground cover maintenance is vital for the a producer looking to maintain vegetation coverage. Temperature regulation is not as convenient in an outdoor facility as it is in confinement and therefore, has proven to be a hurdle in this system. Temperature plays a significant role in the growth rate of pigs raised outdoors, as growth curves depend on season (Brewer and Kliebenstein, 2000). It is vital when producers want to optimize profits. Producers must be willing to raise their hogs outdoors during harsh winters and hot summers. A comparative study found that pasture and confinement rearing had similar outcomes in terms of production results (Brewer and Kliebenstein, 2000). Similar weight gain, feed costs and feed efficiency were found amongst the two treatment groups, yet bedding was necessary for the pasture system. Comparable sow reproductive performance was found, but was dependent upon weather in the pasture system. Outdoor compared to indoor production requires more labor and lower initial and annual costs. There were fewer health problems in the pasture group and less of an odor problem. While confinement systems create greater opportunity for year round production there is a higher cost of heating and cooling (Honeyman, 1991).

Hoop structures like those used at North Carolina Agricultural and Technical State University's Swine unit are ideal for farmers with limited funds to start a swine operation. A hoop structure is a housing unit developed in Canada (SARE Outreach, 2001) that has earthen floors covered by bedding. The hoop is covered by a polyvinyl tarp 15 feet in the air and depending on size can house up to 250 pigs. The tarp is attached to steel beams which reinforce the tarp against strong winds, rain, and other weather adversities. Compared to \$180 per pig space spent on confinement operation costs, the hoop structure cost \$55 per pig space (SARE Outreach, 2001). The average cost to construct a hoop barn ranges from \$9,000 to \$16,200 for a barn that holds 200 pigs (SARE Outreach, 2001). These numbers compared to the \$150,000 to \$200,000 to hold 1,000 pigs indoors (SARE Outreach, 2001) would improve feasibility for a farmer with limited resources. Benefits to this system include the ability to raise pigs in an outdoor environment where they can display normal social behaviors, and to some extent grazing behaviors.

Growth performance traits; average daily gain, feed intake, and feed efficiency, are influenced by gender, genetics, and in some cases environment (Brewer and Kliebenstein, 2000; Kolstad et al., 1996; Latorre et al., 2003; Litten et al., 2004). These traits can be assessed in growing to finishing hogs produced in a hoop structure. The utilization of automatic feeder systems to collect data would be beneficial to evaluating these growth performance traits. An assessment of genetic influences on growth performance will allow producers to select breeds better equipped for outdoor environments and therefore improve economic efficiency.

There is research that evaluates the use of alternative systems. However, other aspects require evaluation including the impact of gestating sows on vegetative cover and growth performance of finishing pigs in these systems. The goal of the producer to maintain vegetative cover while providing grazing forage in pastures, will determine the type of grasses used in their system. Are there some grasses that adapt better to the constant trampling, rooting, wallowing, and foraging behavior of pigs? Or are there grasses preferred over others by gestating sows? These are both questions to consider when analyzing time spent in different grass varieties in a pasture management system. Vegetative cover analysis can then be conducted. These same sows would farrow in a separate pasture and be provided proper shelter and warmth for cooler climates. Piglets would remain with their mothers until weaning. They would then transition to the hoop structure until they reached market weight of approximately 250 pounds. Crossbred offspring of the sows will then be gauged for growth performance traits in a hoop structure using a Feed Intake and Recording Equipment (FIRE) system. Crossbreeding allows producers to select for the best combination of breed characteristics. At the end of the day, a producer wants to utilize the best possible growth characteristics out of their herd to attain maximum profits.

CHAPTER 2

LITERATURE REVIEW

This literature review will discuss outdoor swine production systems, from the breeds used and reproduction methods, to growth performance assessments and use of technology. The following pages provide an in depth look into the methods and equipment used in assessment of factors to determine grass utilization and growth performance in outdoor swine.

2.1 Grass Utilization and Grass Integrity

2.1.1 Swine Breeds. Outdoor pigs are no different from indoor pigs in regards to their basic requirements for food, water, shelter and ability to maintain body temperature. Yet, there are some researchers who argue that select breeds are capable of withstanding the fluctuating temperatures and exposure to natural elements of outdoor production better than others. Breeding stock companies have gone as far as to market gilts specially designed for outdoor production herds (Thornton, 1990). Early reports from the United Kingdom state that the most common breeds used in outdoor systems were a crossbred variety of Saddleback and Landrace (Thornton, 1990). At times the Welsh, Large White (also known as Yorkshire), and Large Black breeds were used as substitutes. Producers during the 1940’s in the United States found themselves using crossbred Yorkshire, Duroc and Hampshire breeds for pork production.

The most common pig in the United States to date is the Yorkshire. This breed was initially imported for its use as a bacon breed. The breed was a preferred source of meat for exportation of Wiltshire-cure bacon to England during the 1850's (Porter, 1993). This breed is described as a white pig with erect ears, medium-length snout with a minor dish, pink skin, and long deep sides (Pukite, 2002). Yorkshires are considered to be one of the longer breeds able to carry weight in excess of 300lbs. Yorkshires are also recognized as Large White, Grand Yorkshire, Large English, Large York, and Large White Yorkshire (Pukite, 2002). Yorkshires are valued for their large litters (average 11 born alive), heavy milk production, and maternal instinct (Oklahoma State University, 1995). This breed characteristics include early sexual maturity, high fecundity and their crossbred offspring experience accelerated growth (Porter, 1993). However, it is vital to note that when used in outdoor production, this breed is prone to sunburn because of its white skin.

The Tamworth pig, with its red hair and dark skin for protection against sunburn, long snout used for rooting, erect ears, and long legs for an active lifestyle, is also known as the Staffordshire (Pukite, 2002). These are deep sided pigs, with narrow backs, firm and trim jowls, and a muscular disposition (Oklahoma State University, 1995). It is deemed one of the oldest commercial hogs in the United States. This pig, which ranges in color from a light to dark red was first introduced to the United States in 1882 as a bacon breed. However, much like the Yorkshire, as consumer demands change, so has the demand for Tamworths. They do not reach maturity as quickly as other breeds and are slow to fatten, reaching a mature weight up to 500-600lbs (Pukite, 2002). The maternal instincts of the sows are excellent. Given the many desired qualities that make this breed ideal for bacon production it is currently listed as threatened (American Livestock Breeds Conservancy, 2009).

A black body and white tipped extremities such as the nose, feet, and tail, are visible in the Berskhire. Short erect ears, short face with a dish, long body with deep sides define characteristics of this breed. Originally, Berkshires were considered a red breed, due to their red sandy coloring that more so resembled a Tamworth. Crossbreeding this breed with Neapolitan and Poland China created what is now known as the Berkshire breed (Oklahoma State University, 1995). Though not as large as some other commercial hog breeds, it has been described as a robust, idyllic outdoor pig whose sows possess excellent mother abilities (Pukite, 2002). Historical reflections explain how Berkshires went through fluctuating points of being produced as a lard hog, then meat type in meeting the economical and consumer demands (Pukite, 2002). As a highly adaptable breed Berkshires are prevalent in sunny regions of the world.

Large Blacks, also known as Cronwall, Devon, and Lop-Eared Black, were a breed of pig once used for lard and has now shifted to a meat and bacon type. These all black pigs, are smaller than Yorkshires, and have large drooping ears that obstruct vision. Resistance to sunburn, grazing ability, and durability have made the Large Black an optimum choice for outdoor rearing (Oklahoma State University, 1995). Sows have great maternal instinct, produce abundant milk, have litters that are large in numbers and rapid growth (Porter, 1993). Females average 20% of the males' maximum 700lbs of body weight (Pukite, 2002).

2.1.2 Reproduction. The main goal of any breeding system is to accomplish high conception rates and good litter sizes, and this can only be achieved by sperm entering the female reproductive tract during estrus (Holden and Ensminger, 2006). The most common method used in the industry is artificial insemination (AI). While it is the most labor intensive, it is the most efficient. Artificial insemination requires producers to deposit semen from a donor boar into the female reproductive tract. It offers the following advantages over the previously mentioned methods: 1) access to semen from valuable or proven boars, 2) decreased disease risk, 3) incorporating new genetics into the breeding program 4) fewer boars required on the farm and 5) decreased risk for injury to the sow. It is recommended that a mature boar should not mate more than two females a day, and artificial insemination makes breeding ten or more sows feasible from one ejaculation (Holden and Ensminger, 2006). As a result AI has improved crossbreeding programs all over the world.

Engineering desired genetic traits in food animals is within grasp. However, current data demonstrates the possibility that the transgene could have an effect on future parities (Paterson et al., 2003). Less invasive techniques available to the average swine farmer, in order to achieve the "ultimate pig" which would grow quicker with a lean body composition; include crossbreeding. It is a common practice in the swine industry, allowing selection of desired traits associated with specific breeds. Most often crossbreeding is done using AI which increases reproductive rate (Visscher et al., 2000). It also saves large farmers money, by eliminating the need to transport a superior boar for mating or reducing the number of boars on the farm. The semen can be used extensively and shipped worldwide.

Several studies have looked at breed and sex difference in growth performance of swine (Kolstad et al., 1996; Litten et al., 2004; Wood et al., 1983). One particular study compared Norwegian Landrace and Duroc on maintenance feed for eight weeks and reported that the Landrace breed had more internal fat and less inter/intramuscular fat (Kolstad et al., 1996) than the Durocs. As pigs mature, fat deposits develop at different rates which cause changes in fat distribution (Wood et al., 1983). While some studies recognize that maternal and paternal lines of pigs influence growth rate they also suggest that underlying mechanisms for this could be resolved through genetic selection (Litten et al., 2004).

2.1.3 Gestating Sows Outdoors. Welfare challenges associated with farrowing and lactating sows from confinement systems have come under scrutiny. Gestating sows are more inclined to develop ulcers, display poor behaviors adapted to the confinement environment, and limited postural adjustments (Johnson, 2007). Outdoor swine production systems on the other hand can be difficult to manage during harsh temperatures. Gestating sows in a pasture environment are exposed to the elements more so than if they were kept in a hoop structure. When these individuals farrow outdoors, their offspring must fight to stay alive in cold winters, hence the importance of farrowing huts.

There are a variety of farrowing hut styles available to producers, making it important to identify types which would be most beneficial to the individual farm. Some styles are the 'A' frame, inverted U, igloo, and arc style. Each may have different shapes, floors, insulation and ventilation openings. They can be made out of plywood, metal or a durable plastic (Honeyman and Roush, 2002; Johnson, 2007). All farrowing huts require some type of straw or hay bedding for insulation. Often times a fender is located at the entrance of the outdoor huts to prevent piglets from leaving the hut as well as keeping the bedding inside the hut (Johnson, 2007). There are two fender designs, one of which is a wooden slat that affixes to a taller metal design at the doorway. The second one used commercially has two or three metal boards that slide into polyvinyl rollers (Johnson, 2007). The height of the fenders can be adjusted to accommodate the sow.

While reports of success with implementation of farrowing huts exist, concern for piglet mortality exists just as it does in the confinement system. Hut type plays a role on prewean piglet mortality (Honeyman and Roush, 2002). Arc style huts and blunt top A huts had one third of the piglet mortalities as those litters in an inverted U hut. This data suggested that the distinguishing factor between the huts was the amount of space inside for the sow and piglets.

2.1.4 Types of Grasses. Kentucky Bluegrass (*poa pratensis L.*) is a cool season perennial, with optimum growth in spring and fall (60 to 90^{o}F). While this type of grass has demonstrated poor seedling vigor and tolerance to drought, it has proven to have excellent tolerance to grazing (Ball et al., 2008). This data justifies its use in pasture swine management, with heavy grazing. Kentucky Bluegrass does not tolerate soil acidity nor poor drainage well, which is an important consideration. It is known to thrive in pastures with a salt pH of 5.3 or higher (Henning and Wheaton, 1993). Overgrazing beyond 1-3 inches is not recommended, as the reduced forage quality impacts the growth rate of the bluegrass (Ball et al., 2008). Kentucky Bluegrass requires high water saturation to supply its dense root system which also fights soil erosion. This grass forage, commonly found in pastures can be mixed with other grasses and legumes by adding two to four pounds per acre of bluegrass.

Tall Fescue (*festuca arundinacea*) is a cool season perennial grass with optimum growth in moist environments. The leaves of this grass are dark green with a minor shine, rough edges, and distinctive veins (Ball et al., 2002). It grows approximately two to four feet tall with a deep root system. Fescue is one of the most tolerant grasses in terms of drought resistance and ability to survive limited fertility conditions (Henning et al., 1993). Not only is this species utilized as forage and hay, but also in pond banks and waterways for erosion control. Tall Fescue is well suited for a wide range of soils and will survive during dry periods in a dormant state. This grass can endure close grazing, usually two to three inches, but if overgrazed will exhibit decreased production and seedling vigor. Maximum production is recorded from September to December and March to July (Ball et al., 2002). Between temperatures of 68^oF to 77^oF, maximum growth rate is observed (Jennings et al., 2008). However, if temperatures above 86^oF or below 40^oF are reached growth rate declines, ceasing in the colder temperature (Jennings et al., 2008). Its adaptation to trampling and grazing has this species designated as a prime grass type for animal performance.

There are currently two categories of Tall Fescue; endophyte-infected (toxic or novel endophyte) and the endophyte-free variety. The endophyte-free strain is best suited for animal grazing, with the endophyte-infected strain known to lead to endophyte toxicity in horses and cattle as well as fescue foot and bovine fat necrosis in cattle (Jennings et al., 2008). Symptoms associated with feeding livestock the endophyte-infected species include reduced conception rates, reduced lactation, intolerance to heat and ample fat masses located in the abdominal cavity (Ball et al., 2002). However, there is minimal research pertaining to performance of pigs on endophyte-infected tall fescue. The fungus allied with Fescue Toxicity, *Neotyphodium coenophialum,* is sustained within tall fescue for its life cycle and produces ergot alkaloids which have been proven detrimental to livestock (Ball et al., 2002). The mutually beneficial relationship between the plant and endophyte appears to have a detrimental effect when consumed by livestock. Kentucky 31 Tall Fescue is one of the endophyte-infected species that benefits from the mutual relationship with good ratings for tolerance to drought, poor drainage, and soil acidity. However, due to the nature in which it affects livestock, it is now being used mainly in turf and grass fields. Jesup MaxQ Fescue is a novel (non-toxic) derivation of endophyte-infected Tall Fescue which has the same advantages as the Kentucky 31, without the toxic endophyte effect. It was developed by Dr's Joe Bouton and Gary-Latch at the University of Georgia and Ag- Research Limited of New Zealand, respectively (Hancock and Andrae, 2009) by inserting novel endophytes into Jesup and GA 5 varieties of Tall Fescue. This resulted in the formation of a tall fescue that did not produce the toxic alkaloid yet retained the desired properties of endophyte-infected Tall Fescue. MaxQ has been extensively tested and used in combination with grasses such as common Bermuda grass where it persevered 85-90% as well as endophyte Tall Fescue

(Andrae and Lacy, 2004). Prior to the evolution of the novel endophyte Tall Fescue, endophyte free was launched as a substitute for endophyte Tall Fescue. Unfortunately, the endophyte free Tall Fescue could not sustain persistent grazing and drought (Jennings et al., 2008) and left much to be desired by farmers. Research and supporting data collected on MaxQ suggest it is of great significance to the agricultural field for pasture grazing systems (Ball et al., 2008).

Bermuda grass (*Cynodon dactylon*) is a warm season perennial indigenous to southeast Africa. As a deeply rooting plant this species withstands intense grazing (usually down to one to two inches), drought, and soil acidity (Ball et al., 2008). This plant is not very tolerant to poor drainage. It is customary to find common Bermuda grass in the southeastern part of the United States, with its narrow leaves, growth between 15 and 24 inches in height and seed head of three to five slender spikes. In North Carolina seasonal production occurs between May and September with an even yield distribution compared to other warm season grasses (Ball et al., 2002). It is spread underground with rhizomes and above ground using stolon, making it difficult to control in row crops as a weed species but perhaps making it somewhat suited for ground cover in pasture pig production. Several varieties of Bermuda grass exist, however they are usually divided up into two categories, coastal and common. Coastal strains have improved resistance to disease compared to common Bermuda grass, however its survival is not sufficient in extreme cold (Hansen and Mammen, 2000). In order to maximize yields throughout the grazing season substantial fertilizer, with nitrogen and potassium, should be applied.

Redtop (*Agrostis palustris)* is a cool season perennial grass that flourishes during the spring and summer. It has a short lifespan, but at mature height reaches two feet tall with a yellow flower, brown seeds, and green foliage. Blooms usually begin to appear in mid-spring, with reddish coloring on the tips of the clustered flowers (Natural Resources Conservation Service, 2011). It is found in wet soils with poor drainage and can tolerate frequent floods, but not drought. *Agrostis palustris* is used for erosion control in ditches and waterways, pastures, and as a temporary turf grass. This grass is distributed all over the United States, yet it is better sustained in the north than the south due to climate differences (Natural Resources Conservation Service, 2011).

2.1.5 Real Time Location Systems. For years wildlife researchers have used real time location systems (RTLS), or global positioning systems (GPS) to track migratory patterns in animal preservation studies (Harris et al., 1990). They can also be used to monitor the speed and direction of moving vehicles. By combining the technology of microchips and global positioning systems, missing animals have been found and returned to their respective owner. The success of these cases has set precedence for implementation into the commercial agriculture industry to help producers. Grazing distribution patterns are monitored through the use of GPS devices, compared to conventional methods. Traditional methods required researchers to physically observe the movement of their subjects, which often lead to interference of animal movement and other errors (Agouridis et al., 2004). Since initial application of GPS technology in livestock research, the cattle industry has used them in numerous research studies (Agouridis et al., 2004; Bailey et al., 2001; Lyons and Machen, 2001; Nagl et al., 2003;

Turner et al., 2000; Ungar et al., 2005). A number of cattle studies have evaluated the accuracy and suitability of GPS collars on cattle in grazing studies (Agouridis et al., 2004; Lyons and Machen, 2001). Data confirmed the capabilities and limitations of GPS collars tracking cattle movement were accurate within four to five meters (Agouridis et al., 2004). Grazing distribution is a matter of concern for all livestock managers, and if not properly managed can lead to unnecessary grazing pressures. Sections of a pasture exhausted by frequent grazing will be destroyed if the livestock are not turned out onto a rotational pasture, or urged to graze in other sections. Animal preference for one area over another is influenced by a number of factors including availability of water, shade, plant types, shelter, soil, and weather. These factors are the main contributors to grazing distribution, aside from the manager's influence. Studies encouraging the use of feed supplements for cattle have utilized GPS devices to track the herd (Bailey et al., 2001). The supplement was placed in a location that would alleviate grazing pressure in one location to counter balance the destructive effect of grazing. The movement of supplements enhanced grazing significantly by shifting the location up to 600m from the supplement (Bailey et al., 2001)

It is important to note that the data attained from GPS devices only allow the researcher to infer the activity of the animal. As confirmed by Ungar et.al (2005), in order to determine the exact behavior of the animal subject, a visual assessment must be performed in parallel. The potential for GPS devices to predict animal activity such as grazing, traveling, and resting is reasonable based on confirmed field observations and data retrieved from devices (Ungar et al., 2005). Aside from inferences of activity, the state of health for an animal can be determined. Location, movement, and health status is monitored when a GPS device is combined with a pulse oximeter, core body temperature sensor, respiration transducer, ambient temperature transducer, and electrode belt (Nagl et al., 2003). A health monitoring system of this variety allows the manager to locate an animal in a large herd, if the animal becomes ill according to the health stats. When an animal is missing on a 300 acre lot, it is convenient for the producer to be able to locate that animal, and supply the medical attention it needs immediately.

2.1.6 Swine Behavior. Pigs display an array of behaviors, much like their human counterparts. They are inquisitive individuals that also posses maternal, sexual, competitive, social, and shelter seeking behaviors (Holden and Ensminger, 2006). Concern for animal welfare has pressured pig producers to develop methods that allow pigs to exhibit natural behavior such as rooting, grazing, wallowing and socializing. Rooting is the act of digging with the snout, it is commonly observed in softer soils, and during warmer temperatures, when the ground is softer. When pigs root, worms, grubs, minerals in the soil, and roots become accessible for consumption. Grazing is the act of feeding on grasses and herbage available in a given area. Pigs raised on pasture with limited feed will graze, provided forage is readily available. How often a pig exhibits this foraging behavior is dependent on the feed and space allowance, as well as quality of grass. Wallowing is often observed after a substantial rainfall, as this can create pools of mud. When pigs wallow, they lie, roll, and splash around in these mud puddles. During the extreme heat of summer months this is a vital cooling method since pigs do not sweat for evaporative cooling.

Recommended spatial allowance for gestating sows is eight to twelve sows per acre (Holden and Ensminger, 2006), which allows ample room for active pigs and exploration. Stocking rate plays a pertinent role in the natural behavior of pigs raised on pasture (Andresen and Redbo, 1999; Rachuonyo et al., 2002; Vittoz and Hainard, 2002). These studies refer to the number of pigs located in an area corresponds with vegetative damage observed; whether growing pigs, or gestating gilts, results across the board lead to this conclusion. In a study by Andrensen and Redbo (1999) twenty growing pigs, divided into four groups were allotted $50m^2$ and then $100m^2$ of grazing area over a three week period. Observation showed that rooting behavior was prevalent in the smaller space, with less energy spent consuming feed (Andresen and Redbo, 1999). In addition to the amount of space provided, length of time spent in a given area impacts loss of vegetation (Dumont et al., 1995; Popp et al., 1997). The study by Andrensen and Redbo (1999), lasted approximately 4.5 weeks, yet if the grazing period was extended, less vegetation would have been observed at the end of the study. Increasing stocking density would have also accelerated vegetation depletion. In addition to the detrimental affects exerted on vegetation, stocking rates influence aggressive behavior in pigs. A large group of pigs, given a specified daily ration, experience heightened competition for feed, space, and positioning in the hierarchal system (McGlone, 1986). Those individuals higher in the system will undoubtedly have greater access to limited feed and water than subordinate members of the social order. Less aggressive feeding behavior is forecasted during feeding time with lower stocking density (Popp et al., 1997). Observations of aggressive feeding behavior, grazing, and rooting diminish, provided the animals are well fed (Rachuonyo et al., 2002). In the study conducted by Stern and Andresen (2003) they observed foraging behavior and daily weight gain of pigs fed 100% or 80% of the indoor nutrient requirements. Over a 6 week period, an increased rooting behavior was detected when pigs were fed 80% of the food allowance, which corresponded with an increase of 5% in herbage intake (Stern and Andresen, 2003). This study also found that allocating new space increased foraging behavior, perhaps by exciting the inquisitive nature of swine.

Sow preference for one particular grass over another can be monitored using video surveillance (Rachuonyo et al., 2005). Researchers were able to monitor walking, eating, grazing, standing, drinking, rooting, time spent under shelter, and lying in a 48 hour period. Pairs of gestating gilts were assigned to four different treatment groups consisting of alfalfa, tall fescue, white clover, and buffalo grass, and monitored for the aforementioned behaviors. It was revealed that gestating gilts spent more time grazing in white clover and alfalfa, while more rooting occurred in the white clover pasture (Rachuonyo et al., 2005). A second trial revealed that gilts preferred alfalfa over the other grasses, once white clover was no longer available. From this study, producers, whose primary aim is to forego foraging, would utilize buffalo grass and tall fescue, to maintain vegetation coverage. In another study (Dailey and McGlone, 1997) which compared pregnant gilts outdoors to their indoor counterparts, it was found that the outdoor group spent more active time such as grazing, walking, and drinking. This would be expected for outdoor pigs allotted more space to explore and socialize.

Rooting and wallowing are dependent upon soil integrity. The softness and wetness of soil are indicative of the ease at which the pig will be able to root and wallow (Vittoz and Hainard, 2002). The purpose of the Vittoz and Hainard study was to assess the impact that free-range pigs have on vegetation survival and re-cultivating in the mountainous region of Swiss Jura. Researchers found that the growing pigs demonstrated a preference for soft, wet, and deeper soils that contained nutrients, earthworms, and *Crocus* bulbs. Heady (1964) supports this observation, using palatability as the determining factor for animal preference. The chemical makeup of plants is altered based on the nutrients available in the soil. Grazing patterns of animals differ according to soil texture, drought cycles, weather, and topography (Heady, 1964). In accordance with the goal of the study, researchers found that the four plant varieties were not ideal for maintaining pasture in this region. After four years the plants had not sufficiently recovered from abuse by the pigs.

2.2 Growth Performance

2.2.1 Paternal and Maternal Line Influence on Growth. The United Kingdom has been selecting Landrace and Large White pig breeds to increase rate of muscle accumulation and lower carcass fats for many years. It is known that gender plays a significant role on growth performance. Boars exhibit the fastest growth rate and leanest carcasses while consuming the least amount of food compared to barrows and gilts (Latorre et al., 2003). Barrows consume the most feed, have fatter carcasses with average growth rate. Gilts consume an average amount of feed, slow growth rate, and average carcass leanness (Pitcher, 1997). Females accumulate more fat over a given period of time. Males gain protein faster, signaling that they use their feed more efficiently in terms of growth. The Latorre (2003) study found that boars of the Danish Duroc breed grew faster and demonstrated better feed conversion than their Pietrain x Large White counterparts.

Not only is it necessary to look at the growth rate but, its components as well. A market hog may weigh 250 lbs, but if that 250 lbs is comprised of mainly fat, the demand and profit margin for that carcass decreases. Studies that assess the composition of growth performance in differing breeds can help producers select pigs with improved growth efficiency. Genetics plays a pronounced role in growth performance, and naturally breeds that perform better than others are preferred. The sire line is known for its contributions to growth and carcass attributes hence the importance of research that examines this role. Mating purebred Large White boars to sows with dominant Duroc genes yielded offspring with superior growth rate and a higher ad libitum feed intake (Litten et al., 2004)

Few studies have compared performance of Yorkshire, Berkshire, or Large Black breeds in outdoor systems in the western part of the world. Whether from the perspective of the sire line affecting growth rate or maternal line, more emphasis is needed in this area. In order for the US to meet consumer demand for pasture pork more studies are necessary using various breeds in the US.

2.2.2 Automated Feeding Equipment. Automated feeders used for research purposes are relatively new to the field of agricultural research. Most often breeding stock supply organizations use them to conduct performance testing of group housed pigs (Ellis, 1998). This way, breeding organizations are able to observe animals under the social conditions found in commercial operations. Feed intake recording equipment is frequently used with growing-finishing pigs, approximately 20 to 150 kilograms in weight. While there have been several computerized feeders in production, they all function similarly. The equipment consists of an individual feed trough attached to a load cell, weighing platform attached to a separate load cell, protective race, and antenna to read the pig transponders, control equipment and computer. Very little labor is required for operation of this feeding equipment. Each time a pig enters a single feeder station, the antenna reads the transponder located on the pig's ear, weighs the pig, records the amount of feed consumed, and the time spent in the feeder is calculated by recording when the pig entered and exited. Feed Intake Recording Equipment (FIRE) by Osborne Industries is an example of the computerized feeder used for testing breeding stock, and was the one used for this study.

Several observations can be made from the use of these computerized feeders, such as; feed intake behavior, individual variations in feeding behavior, the impact of sire line on feed intake and growth performance as well as, significance of stocking density on growth performance. In a study assessing the impact that increased group size had on growth performance of finishing pigs fed on FIRE feeders and conventional feeders, there was no significant difference (Hyun and Ellis, 2002). In fact, feed intake was lower and feed:gain ratio was higher for pigs on the FIREs. This scenario is vital to a producer looking to optimize feed supply and growth performance of their stock. This experiment consisted of four treatment groups in sizes two, four, eight, and twelve. As the group size increased diurnal variation pertaining to the number of feeder visits and consumption per hour decreased (Hyun and Ellis, 2002). Automatic feeders only provide access for one pig at a time to feed, unlike conventional troughs, where multiple pigs have access. As there is only one access point, increased competition for feed would normally be observed, with the dominant members of the pack getting prime selection (Nielsen et al., 1995) In efforts to observe individual and behavioral performance, groups of five, ten, fifteen, and twenty were composed to manipulate feeder competition. The largest group of pigs stayed in the feeder longer per visit, ate faster, and consumed more feed on average compared to the member of smaller groups (Nielsen et al., 1995). However, the live weight gain displayed no significant difference among the group sizes. This lack of a difference suggests that the pigs can adapt to the competitive environment associated with single space automatic feeders by altering their feeding behavior (Young and Lawrence, 1994).

Stocking density plays a key role in any livestock management system, and can affect growth performance. Gender is another consideration for impacting growth rate in swine. It is known that boars have the fastest growth rate and leanest carcasses, while consuming the least amount of feed. Yet, barrows, castrated males, have the highest feed consumption rate and fattest carcasses. Gilts, young females, can be viewed as the medium successor between the two, with efficient feed intake and lean carcass, yet the slowest growth out of the three (Pitcher, 1997). For a producer looking to optimize growth performance on the automated feeders a study such as that conducted by Hyun et al., (1997) would be beneficial. The growth performance of the three sexes; barrow, gilt, and boar were observed for differences in feeding behavior, and found to be small (Hyun et al., 1997). The boars in this study had a feed consumption rate of 24.1 grams/minute, compared to barrows' 23.6 grams/minute, and the gilts' 23.4 grams/minute (Hyun et al., 1997). This difference between average consumption rates, suggests that boars were able to dominate time spent on the feeders and consuming feed. The average daily gain was higher for boars and barrows than gilts. From the Hyun et al., (1997) study the feed:gain ratio, from greatest to least was boars, barrows, and gilts. Similar results were found by Kolstad et al., (1996), as the boars demonstrated more inter and intramuscular fat than subcutaneous fat compared to gilts in the study (Kolstad et al., 1996). At the Polytechnical University of Madrid, in a study comparing performance of barrows and gilts, it was concluded that barrows ate more and grew faster. However, the barrows converted feed less efficiently and produced more fat than leaner cuts of meat compared to gilts (Latorre et al., 2003).

CHAPTER 3

MATERIALS AND METHODS

3.1 Evaluations of Time Spent Utilizing Grass

Grass seeds from Southern States (Reidsville, NC) were planted at the North Carolina A & T State University Swine Unit during the spring of 2009 (Figure 3.1). The 100m x 50m (1.23 acres) pasture consisted of four different sections containing; 1) Kentucky 31 Tall Fescue, 2) Max Q Fescue, 3) multispecies grasses including Redtop, Kentucky Bluegrass, and Kentucky 31 Fescue and 4) common Bermuda grass.

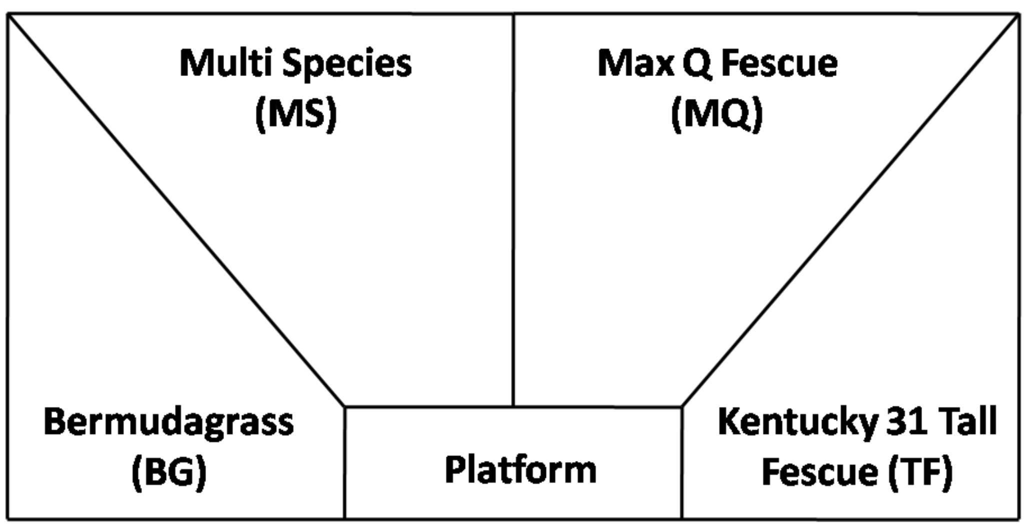

Figure 3.1. Diagram of the grass pasture at the North Carolina A and T State University Swine Unit.

Six gestating antibiotic free Yorkshire female pigs were randomly assigned to the aforementioned pasture for four trials; 1) Spring, May 1, 2009 - May 22, 2009, a total of 22 days 2) Summer to Fall, August 17, 2009 - October 15, 2009, a 60 day trial 3) Winter, February 26, 2010 - March 27, 2010, for a total of 30 days, and 4) Spring to Summer, June 14, 2010 – August 23, 2010, a 71 day trial. Seasons for the trials were assigned based on the Old Farmer's ALMANAC which designates seasons by the earth's orbit around the sun and tilt of the earth's axis. The antibiotic free gilts were procured from the Center for Environmental Farming Systems (CEFS) in Goldsboro, North Carolina. Pigs at CEFS have been raised for generations without use of antibiotics. During gestation, gilts were fed approximately 26.6 kg daily of commercial 15% crude protein gestation ration purchased from Southern States (Reidsville, NC) (See Appendix A).

At the start of this project, gilts were 1.1 years of age. During the first trial they were bred between January 31, 2009 and February 3, 2009 with semen from Yorkshire (Y), Large Black (LB), or Berkshire (B) boars from the International Boar Semen (IBS) company in Eldora, Iowa. Semen samples for each breed were collected and pooled from three different boars from IBS. Six of the eighteen gilts inseminated for the spring trial were randomly selected for this study. A total of sixteen Yorkshire sows and gilts were artificially inseminated with semen from LB, Y, or B boars from June 30, 2009 – July 4, 2009. Of the sixteen, six were randomly selected to go into the pasture. The third trial was conducted during the winter of 2010. The 19 sows involved in this were bred December 8, 2009 – December 11, 2009. These sows were inseminated with B or Y semen from IBS, or Tamworth (T) boar semen from Paul Morrison of Ohio (See

Appendix B Table 5). The twenty-three sows inseminated during the fourth trial were inseminated with semen from LB, Y. or T boars from May 5, 2010 – May 10, 2010.

Each of the six Yorkshire sows for each trial was allotted a Super Trackstick (Telespial Systems, Burbank, CA) in weatherproof casing to monitor movement and location within the paddock. All units had four megabytes of flash memory which was later transferred to a computer using a USB 2.0 connection. Powering the devices were two lithium AAA batteries whose life expectancy was one to two weeks, depending on signal strength. To ensure power, the batteries were changed once every three to four days during this study. Operating temperatures were between -30° to 80° C (-22° to 176° F). Twelve satellites tracked each device at all times. The device was placed in a zippered plastic bag, put into a pvc pipe sealed off at both ends and fitted like a collar tied around the pig's forerib area (Figure 3.2). Though the unit had weather proof casing, it was placed in the plastic bag to prevent as much moisture and mud from coming in contact with the device as possible. The geographic information system (GIS), Trackstick Manager, had to be downloaded from the manufacturer's website in order to view the data logged. Supertrack Trackstick reports date and time, latitude and longitude, temperature, altitude, direction the animal was moving, speed, cease of movement and signal strength. Integration directly into Google Earth allows for visualization of movement in the designated area.

Once the trial was complete all data from the Super Tracksticks were pooled together in an Excel spreadsheet showing the sow, latitude and longitude of each stop, and how long the sow stopped. A defect with the Super Trackstick for sow two in trial two resulted in the removal of that sow from trial two. Another malfunctioning Super Trackstick at the culmination of trial four led to complete removal of the trial from the study. Remaining information was analyzed in SAS to determine which of the four grass sections in the paddock was occupied the most by the sows.

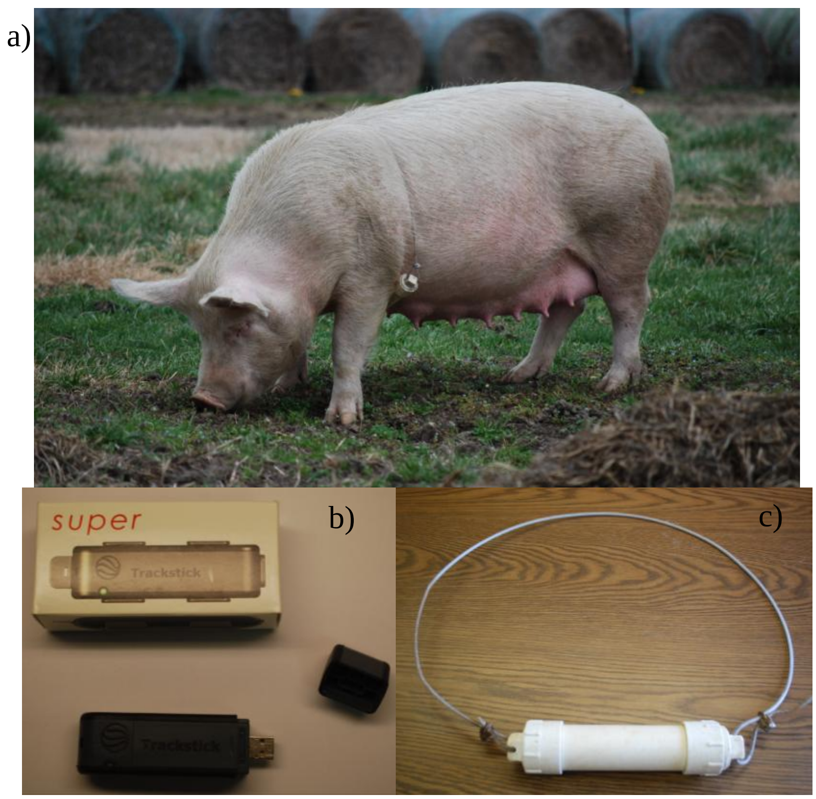

Figure 3.2. Subject and equipment used in grazing trial. A sow grazing in the pasture with the GPS collar tied around the fore rib (a). GPS device, Super Trackstick by Telespial Systems (b), and GPS collar (c).

At the conclusion of each trial sows were transferred to a farrowing area. Group feeders and waterers were accessible to all sows farrowing in the pasture environment.

While nursing, sows were fed a 19% crude protein lactation ration from Southern States (Reidsville, NC) (See Appendix A).

Pigs from the sows in the third grass utilization trial were weaned at 30 days (April 30, 2010) after birth and moved to the hoop structure (See Appendix E, Table14). Sows were turned out to a temporary pasture before being inseminated for the next trial. From weaning until two months, the pigs were fed an 18% crude protein Grower diet from Southern States (Reidsville, NC) (See Appendix A). At the two month mark, May 30, 2010, offspring from sows involved in the third grass utilization trial started on the 16% crude protein finishing ration in the nursery hoop (Southern States, Reidsville, NC) (See Appendix A).

3.2 Evaluation of Grass Integrity

A vegetative cover analysis was conducted to assess grass durability throughout the pasture. Grass scores, defined as a measurement of grass integrity, were assigned after trial two and trial three. Grass integrity is an estimate of vegetative cover in pastures. Grass scores of 0, 1, 2 and 3 were assigned to the entire pasture by a walk through assessment. In efforts to expedite the evaluation, one to six members of the staff at the swine unit assisted in assigning scores at varying times. Walking the width and length of the pasture, at each completion of a stride, the area at the stride end was assigned a score. The scores were defined as follows 0 = no cover, 1 = partial cover, 2 = moderate cover and 3 = complete cover.

3.3 Growth Trial

The offspring from the third grazing trial were used in the growth performance assessment. Of the 76 piglets that were born the spring of 2010, 45 were used in the growth performance trial from September 8, 2010 until November 17, 2010 (70 days). The 45 Tamworth x Yorkshire, Berkshire x Yorkshire, and Yorkshire x Yorkshire had access to feed ad libitum using eight single space automatic, Feed Intake and Recording Equipment (FIRE) feeders, (Osborne Industries Inc., Osborne, KS). Nineteen (42.2%) of the 45 pigs were barrows (males) and the remaining 26 (57.8%) were gilts (female). Twenty- five (55.5%) were Berkshire x Yorkshire crosses, eight (17.7%) were Yorkshire x Yorkshire cross, and twelve (26.6%) Tamworth x Yorkshire. Each pig was tagged with a radio frequency identification (RFID) tag in the right ear before entering the hoop structure with the feeders (Figure 3.3). They were provided a 16% crude protein commercial finishing ration ad libitum (Southern States, Reidsville, NC) (See Appendix A).

The FIRE feeders read the RFID tag, weigh the pig, and record how much feed was consumed. These feeders are equipped to monitor the time spent at each station and number of visits per pig. Once a week, the data were electronically retrieved from the feeders and stored on a hard drive for further investigation. Once a week the feeders were cleaned to maintain optimum performance. On November 17, 2010, when the pigs averaged 201 days of age and 143 kg bodyweight they were harvested at a USDA-inspected abattoir. Average daily gain, feed efficiency, and average feed intake were then analyzed using SAS. Piglets were placed on the FIRE feeders September 8, 2010;

however the FIREs did not start collecting data until September 11, 2010, for a trial total of 67 days. Due to an error in the feeders, only data for 40 of the 45 pigs was available for analysis. Nineteen (47.5%) of the 40 pigs were barrows and the remaining 21 (52.5%) were gilts (female). Twenty-three (57.5%) were Berkshire x Yorkshire crosses, six (15%) were Yorkshire x Yorkshire cross, and eleven (27.5%) Tamworth x Yorkshire.

Figure 3.3. Hoop structure at North Carolina A&T State University Farm Swine Unit.

3.4 Statistical Analysis

Statistical analysis for the grass utilization trials were conducted after data had been collected on all available trials using Statistical Analysis System (SAS) (SAS Institute, Cary, NC) and Microsoft Excel. The longitude and latitude values were reconfigured for use in SAS to include as many data points within the pasture coordinates. Pairwise comparison was done to determine the length of time the sows spent in various paddocks. Proc GLM was used to compute the arithmetic mean and standard deviation of the values, as well as a percentage calculation and least squared means statement. The results of these tests were then used to compute the length of time spent in the various paddocks for the duration of the study as a percentage. Duncan's Multiple Range test was done to assess any significant difference between the length of time spent in the paddocks. Results were then displayed in a graph using GraphPad Prism (GraphPad Prism, La Jolla CA)

For the evaluation of grass integrity an Excel spreadsheet with the grass scores for each trial was analyzed for the percentage of scores 0,1,2, and 3. The scores where then compared in a Duncan's Multiple Range test for significant difference. Results were displayed in a graph using Graph Pad Prism (GraphPad Prism, La Jolla, CA)

Calculated values for average daily gain and feed efficiency were computed in SAS and feed intake was collected by the FIREs. A two way Analysis of Variance (ANOVA) was conducted with breed and sex as the variables. Duncan's Multiple Range test was also done to compare values and detect significant difference. Tables were made in Microsoft Excel to display results.

Figure 3.4. Equipment used for growth performance study. Radio Frequency Identification Tag (RFID) used to identify pigs with the FIRE system (a). Feed Intake and Recording Equipment (FIRE), and in the hoop structure (b and c)

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Percentage of Time Utilizing Grasses

Figure 4.1 is a synopsis of the percentage of time all sows spent in the various grass sections; BG = Bermuda grass, MS = Multispecies grasses, MQ = Max Q Fescue, TF = Kentucky 31 Tall Fescue, and the platform.

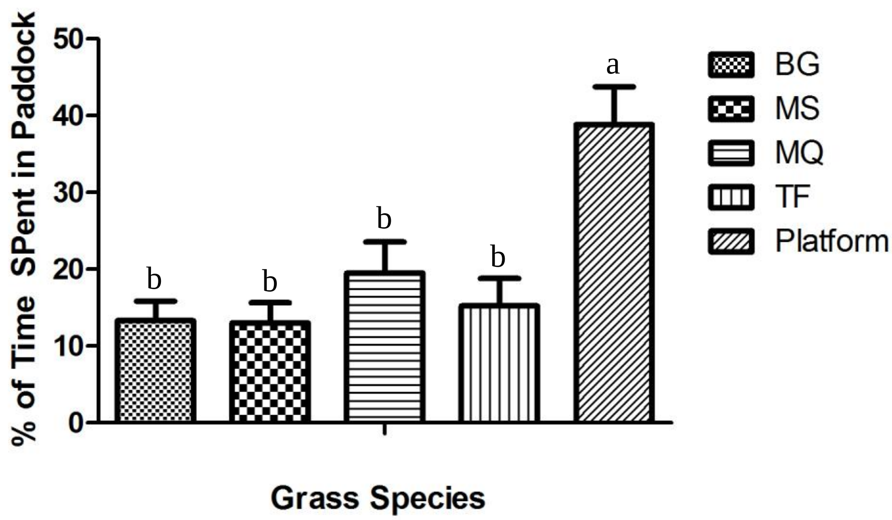

Figure 4.1. Percentage of time spent in grass sections. [a,b]Means having a letter in common are not significantly different at the 5% level of signifiance as indicated by Duncan's Multiple Range test ±0.1. BG= Bermuda grass, MS= Multispecies, MQ= Max Q Fescue, TF= Kentucky 31 Tall Fescue.

There was a significant difference among the platform time and individual grass sections; BG = 13.95%, MS = 13.87%, MQ = 18.94%, TF = 15.76%, and platform = 37.46%, as calculated by Duncan's Multiple Range test in SAS. There was no difference ($p>0.05$) among the four grasses in percentage of time spent in those areas. It was hypothesized that the sows would spend more time in one or more grasses over the other. The sows spent a total of 62.52% of their time in the grasses, yet time spent in the individual grass sections were all less than the time spent on the platform (See Figure 4.2). One possible explanation for BG = 13.95%, MS = 13.87%, MQ = 18.94%, TF = 15.76%, and platform = 37.46%, is that the basic necessities for survival were located on the platform; water, feed, and shelter. Sows were fed once a day, in the morning, which should have allowed plenty of time to graze. Still, sows spent 62.52% of their time in the grasses compared to 37.46% on the platform.

It is pertinent to comment that the GPS devices are only capable of providing location and movement of the sows in the pasture. The actual activity of these sows; grazing, rooting, wallowing, or playing cannot be accounted for solely upon data acquired through the GPS. Other factors that may have affected the outcome of these trials include season, amount of feed supplied for the day, and activities immediately outside the confines of the pasture drawing the attention of the animals. During the summer months, the sows may have more desire for protection from the shelter on the platform. The same could be said for the winter months with the snow and rainy seasons. However a SAS analysis by trial, showed no significant difference by trial.

The concentration of sows in the platform area when comparing the platform to the grasses is similar to results observed in cattle (Lyons and Machen, 2001). This research team found that water availability impacts grazing distribution. When water was available in the north end of the pasture, the cattle often preferred grazing within 0.6 miles of the watering site (Lyons and Machen, 2001). In the current study, the watering troughs were located on the platform. Thus, sows were not encouraged to move from the feed, water, and shelter area. Another point that influences grazing distribution of the livestock is age (Lyons and Machen, 2001). The sows used in this study were only 1.1 years old, but they were gestating, which influenced their maneuvering ability. More energy was exerted to carry the weight of the sow plus the fetuses, compared to when open.

While GPS technology has improved the quality of research in a variety of fields, there are limitations that must be accounted for when analyzing data for studies such as this. There are three aspects which control operation of GPS devices; space, control, and user segments (Turner et al., 2000). Space pertains to the satellites in space which sends accurate radio signals to the unit. Control segment refers to the network of stations on earth which monitor the satellite information. The user segment indicates the units that convert the signal from the satellites to location and movement. All of these conditions work in conjunction to provide the accurate location and movement data generated. However, there are deviations with satellites including positioning and clock errors impacting accuracy. The receivers are also capable of misreading time. Multi-path inaccuracies are produced by radio signals reflecting off large objects. At any point during the experiment, one or more of these errors could have influenced the data, in addition to battery issues and the sows losing transponders.

4.2 Variations in Grass Integrity

Although not influenced by grass type overall, there were more grass integrity scores of two (37.92%) and three (38.57%) compared to zero (8.45%) and one (15.02%).

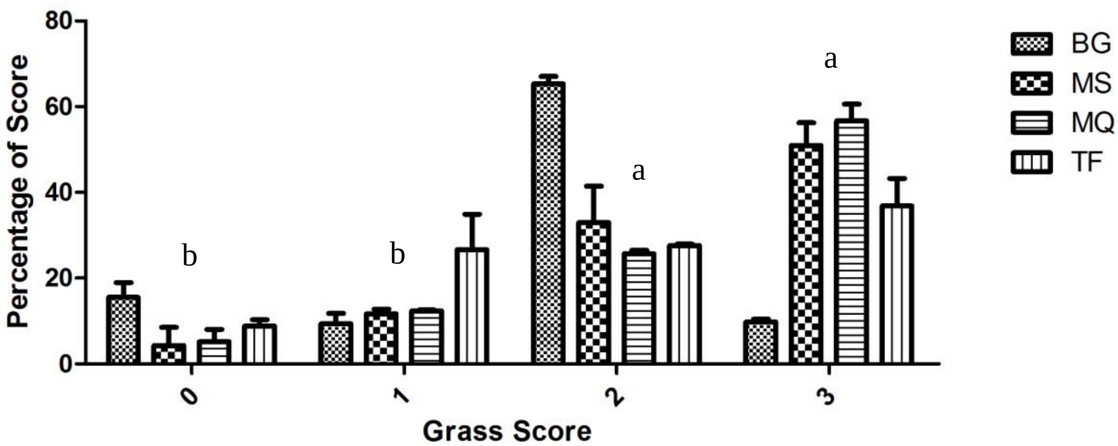

Figure 4.2. Grass Integrity: Summary of Trials 2 and 3. [a,b]Means having a letter in common are not significantly different at the 5% level of signifiance as indicated by Duncan’s Multiple Range test ± 0.2. Grass scores 0-3, 0= no cover, 1= partial cover, 2= moderate cover, 3= complete cover. ***BG= Bermudagrass, MS= Multispecies, MQ= Max Q Fescue, TF= Kentucky 31 Tall Fescue.

The overall objective of this study was to determine which of the grass types could withstand grazing pressures from traffic by the gestating sows. Surprisingly however, no differences were observed for the grass type by trial. One might suspect that a grazing trial held during the summer to fall versus a winter trial would show a difference in grass integrity analysis after removal of sows from pasture. With Kentucky Bluegrass, the fescue species, and Redtop being cool season perennials, greater vegetative cover was anticipated during the fall, possibly carrying into early winter. Perhaps if more than one pasture were used for repeat sites or if additional animals (greater stocking rate) were used, results may have been different.

4.3 Growth Trial

Feed intake, growth performance, and average daily gain for the 40 pigs with different breed of sire for 67 days is summarized (Table 4.1). The same growth traits are summarized in Table 4.2 based on gender. There was no significant difference in growth performance based on breed, but there were differences based on gender.

Expected values of feed intake per day for finishing hogs are 2.4- 3.3 kg, for average daily gain 1.2 kg per day is normal, and feed efficiency is 2.0- 2.9 (Holden and Ensminger, 2006). Feed intake for this study averaged 1.5 kg for all crossbred pigs. The average daily gain for all crossbreds was 1.52 kg. The average for feed efficiency for all three crossbreeds was 0.99 kg.

Table 4.1. Effect of Breed of Sire on Growth Performance of Finishing Hogs Raised in an Outdoor System

Breed	Number of Piglets	Days in Trial	Feed Intake (kg)	Average Daily Gain (kg)	Feed Efficiency (kg)
Yorkshire	6	60	1.5[a]	1.5[a]	1.0[a]
Berkshire	23	60	1.4[a]	1.4[a]	0.9[a]
Tamworth	11	60	1.5[a]	1.5[a]	1.0[a]

[a] = mean values with the same letter in a column are not significantly different (p> 0.05). Feed intake ±0.04, Average Daily Gain ±0.02, Feed Efficiency ±0.01.

It has been reported that maternal and paternal lines influence growth rate according to genetic makeup (Augspurger et al., 2002; Latorre et al., 2003; Litten et al., 2004; Swali and Wathes, 2006). Litten et al., (2004) found that in comparison to the crossbred German Pietran sire line, the crossbred Duroc x Large White progeny had superior growth rates, with higher feed intake. However, the feed efficiency ratio was not improved in this study. Another study compared the effects of sex and terminal sire on Danish Duroc (DD) crossbreds to Pietrain x Large White (PxLW) and found that the DD crossbreds utilized feed better and grew faster (Latorre et al., 2003). Latorre et al., (2003) results differed from Hyun et al., (2002) data which showed no significant difference in daily feed intake, average daily gain nor feed efficiency in crossbred subjects.

Means of feed intake and feed efficiency differed significantly (p > 0.05) between the sexes (See Table 4.2). The average daily gain values between males and females did not differ significantly. Feed intake, feed to gain ratio, and feed efficiency were 1.6 1kg, 1.55 kg, and 1.03 kg respectively for barrows. Feed intake value of 1.41 kg, feed to gain ratio of 1.47 kg, and feed efficiency of 0.95 kg was measured for gilts in the study. This data suggests that while feed efficiency and feed intake did not differ among the sexes when average daily gain did, females used their feed more efficiently. The females consumed less feed but were able to use that feed more efficiently to attain average daily gains similar to barrows.

Table 4.2. Effect of Gender on Growth Performance of Finishing Hogs Raised in an Outdoor System

Gender	Number of Piglets	Days in Trial	Feed Intake (kg)	Average Daily Gain (kg)	Feed Efficiency (kg)
Male	19	60	1.6[a]	1.5[a]	1.0[a]
Female	21	60	1.4[b]	1.4[a]	0.9[b]

[a] = mean values with the same letter in a column are not significantly different ($p > 0.05$).
Feed intake ±0.04, Average Daily Gain ±0.02, Feed Efficiency ±0.01.

Differences in growth performance among genders has been reported in numerous studies (Aregheore, 1995; Latorre et al., 2003; Mikesell and Kephart, 1999; Serrano et al., 2008; Yilmaz et al., 2007). Latorre et al., (2003), found that barrows grew faster with higher food consumption and poorer feed efficiency compared to gilts. Boars exhibit the fastest growth rate and leanest carcasses while consuming the least amount of food (compared to barrows and gilts, (Pitcher, 1997). Gilts consume an average amount of feed, have slower growth rates, and average carcass leanness (Pitcher, 1997). Males gain muscle faster, signaling that they use their feed protein more efficiently in terms of growth. Pennsylvania State University researchers found that barrows housed separately from gilts had improved growth performance (Mikesell and Kephart, 1999). The current study did not focus on separation by gender like Mikesell et al., (1999) but, the barrows in this study had higher average daily gains, which is similar to findings by Mikesell et al., (1999).

A number of factors could have contributed to the unexpected results acquired in the current study. The study began with all eight FIRE feeders operating in the hoop structure; however, throughout the course of the study, a number of issues surfaced (i.e., mechanical, electrical, and technical operation of the weigh stations) reducing the number to three to four feeders at a time. As the number of available feeders decreased, competition for feeders increased, creating a more severe social hierarchy. The dominant members of the group would have more access to the feeder at these times. A regular cleaning and calibration schedule was established to circumvent interference from rodents that caused part of the problems noted. The age of the equipment, as suggested by the Osborne technician, may also have contributed to the frequent mechanical issues. Finishing hogs in this type of feeding system were not recommended unless they weighed a minimum of 45.45 kg; some of the pigs on this study were below that amount. As such, double occupancy was sometimes observed at the stations with undersized pigs. This scenario led to misreading of animal weights. Chewing behavior of pigs on others' ear tags caused some RFIDs to fall out requiring replacement. When the RFID was missing, data was not collected for the particular animal. Automatic feeders, like the FIRE system are known to produce data with errors generated by feeder malfunctions and animal-feeder interactions (Casey et al., 2005), some issues were expected.

CHAPTER 5

SUMMARY

The current study results indicate that there were no differences in frequency of time sows spent in sections of a pasture with various grass types. Although they did spend more time on grass overall compared to the platform, they spent more time at the platform than in individual grass type areas (see Figure 4.3). The platform area provided two watering points, shelter, and was the site of daily feeding. Regardless of the lack of differences among grass types and trial, there was a difference in the frequency of scores. The higher frequency of two and three scores show that, overall, the pasture maintained moderate to complete cover (Figure 4.3). This is expected based on sow concentration in the platform area. The current study had six sows per 1.23 acres, while the recommended spatial allowance is eight to twelve gestating sows per acre (Holden and Ensminger, 2006) so perhaps a higher stocking rate would change results.

In the growth performance study, there were no differences due to breed of sire found on average daily gain, feed intake, and feed efficiency of pigs raised in a hoop barn (See Table 4.1); perhaps more pigs per breed type would have changed results. Feed intake was not significantly different ($p > 0.05$) between the YxY cross (1.5 kg), YxB cross (1.4 kg) or YxT cross (1.5 kg). The average daily gain for all crossbreds was 1.5 kg. The average for feed efficiency between the three crossbreeds was 0.9 kg. Means of feed intake, average daily gain, feed efficiency, did not differ significantly ($p > 0.05$) between the sexes (Table 4.2). Feed intake, feed to gain ratio, and feed efficiency were

1.6 kg, 1.5 kg, and 1.0 3kg respectively for barrows. Feed intake value of 1.4 kg, feed to gain ratio of 1.4 kg, and feed efficiency of 0.9 kg was obtained for gilts in the study.

CHAPTER 6

CONCLUSION AND RECOMMENDATIONS

For future trials, seasonal comparison would be beneficial to attain better data. Since the GPS devices can only define location and movement, implementation of a surveillance system with visual recording equipment would show the actual activity of the sow. The amount of time spent in particular paddocks grazing, rooting, or wallowing could then be compared to the grass integrity of specific paddocks. The incorporation of visual surveillance, GPS device use, and grass scoring would provide a better method for determining exact activity of the gestating sows. In addition, if the grass could be re-seeded before or after trials, so that initial conditions, (full vegetative cover in the pasture) were used this would allow for better assessment of grass integrity. This is suggested, as opposed to seeding once and continuing to evaluate grass integrity. Grass integrity evaluations before and after grass utilization trials would allow for a better comparison of vegetative cover. An analysis of soil quality and plant maturity should also be accounted for in future trials. Increase stocking rate and increasing the number of pasture replicates is suggested.

The growth performance study demonstrated no significant difference between breed of sire of pigs (Yorkshire, Tamworth, or Berkshire). However, a difference in two growth traits was observed for gender comparison. A larger number of subjects in future studies would be statistically beneficial and could possibly result in different data findings. Some studies have reported that season influences growth performance (Brewer and Kliebenstein, 2000; Yilmaz et al., 2007) and future replications of the current study could incorporate seasonal trials. Improved feed intake and recording equipment and management is also advised to ensure quality data is retrieved. A study that assessed growth performance of crossbred finishing hogs fed different protein levels may be beneficial to the growth aspect of outdoor production or for different crossbreds. Future studies may also find it beneficial to incorporate portable watering and/or feeding sites to see if location of feed and water influences animal movement and forage utilization.

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APPENDIX A

FEED SPECFICATIONS

A) Gestation Ration:

Crude Protein	(min.) 15.00%
Lysine	(min) 0.65%
Crude Fat	(min.) 4.25%
Crude Fiber	(min) 6.00%
Calcium (min.) 0.93%	(max.) 1.42%
Phosphorus	(min.) 0.85%
Salt (min.) 0.15%	(max.) 0.65%
Selenium	(min.) 0.30 ppm
Zinc	(min.) 165 ppm

B) Lactation Ration:

Crude Protein	(min.) 19.00%
Lysine	(min) 1.05%
Crude Fat	(min.) 4.75%
Crude Fiber	(min) 4.00%
Calcium (min.) 0.95%	(max.) 1.45%
Phosphorus	(min.) 0.80%
Salt (min.) 0.10%	(max.) 0.60%
Selenium	(min.) 0.30 ppm
Zinc	(min.) 155 ppm

C) Grower Ration:

Crude Protein	(min.) 18.00%
Lysine	(min) 1.10%
Crude Fat	(min.) 5.00%
Crude Fiber	(min) 4.00%
Calcium (min.) 0.61%	(max.) 1.11%
Phosphorus	(min.) 0.55%
Salt (min.) 0.15%	(max.) 0.65%
Selenium	(min.) 0.30 ppm
Zinc	(min.) 150 ppm

D) Finisher Ration:

Crude Protein	(min.)	16.00%
Lysine	(min)	0.90%
Crude Fat	(min.)	3.35%
Crude Fiber	(min)	5.00%
Calcium (min.) 0.58%	(max.)	1.08%
Phosphorus	(min.)	0.54%
Salt (min.) 0.25%	(max.)	0.75%
Selenium	(min.)	0.30 ppm
Zinc	(min.)	110 ppm

APPENDIX B

PRODUCTIVITY INFORMATION FOR SOWS IN GRAZING TRIALS

Table 1. Breed and Productivity of Grass Utiliaztion Sows: Trial 1

No.	Sow	Boar Breed	Born Alive	No. of Weaned Piglets	Parity	
1	595	B	10	10	1	
2	147	B	9	9	1	
3	143	Y	9	9	1	
4	130	LB	7	7	1	
5	137	Y	14	14	1	
6	126	LB	11	9	1	
7	125	B	11	7	1	
8	121	LB	7	7	1	
9	120	Y	7	7	1	
10	115	LB	9	9	1	
11	110	B	7	7	1	
12	104	B	10	9	1	
13	85	Y	9	8	1	
14	83	Y	9	9	1	
15	80	Y	11	9	1	
16	79	Y	9	9	1	
17	76	Y	13	6	1	
18	70	B	11	9	1	
			9.61	**8.56**		**Total Average**

Table 2. Sire Breed Productivity of Grass Utilization Sows: Trial 1

No. of Sows	Sire Breed	Total Born Alive	Average Born Alive	Total # of Weaned Piglets	Average Weaned
6	B	58	9.6	51	8.5
8	Y	81	10.12	71	8.87
4	LB	34	8.5	32	8

Table 3. Breed and Productivity of Grass Utilization Sows: Trial 2						
No.	**Sow**	**Boar Breed**	**Born Alive**	**No. of Weaned Piglets**	**Parity**	
1	147	B	6	2	2	
2	143	Y	2	2	2	
3	137	B	7	6	2	
4	126	Y	7	7	2	
5	125	Y	13	13	2	
6	120	B	3	0	2	
7	115	B	9	9	2	
8	110	LB	6	2	2	
9	104	B	9	9	2	
10	85	B	3	3	2	
11	80	Y	15	9	2	
12	76	LB	10	10	2	
13	504	B	9	9	1	
14	97	LB	3	0	1	
15	74	B	11	10	1	
16	47	LB	10	10	1	
			7.69	**6.31**		**Total Average**

Table 4. Sire Breed Productivity of Grass Utilization Sows: Trial 2					
No. of Sows	**Sire Breed**	**Total Born Alive**	**Average Born Alive**	**Total # of Weaned Piglets**	**Average Weaned**
8	B	57	7.12	48	6
4	Y	37	9.25	31	7.75
4	LB	29	7.25	22	5.5

Table 5. Breed and Productivity Grass Utilization Sows: Trial 3						
No.	**Sow**	**Boar Breed**	**Born Alive**	**No. of Weaned Piglets**	**Parity**	
1	595	T	12	0	2	
2	121	B	0	0	2	
3	79	Y	15	11	2	
4	70	Y	10	5	2	
5	502	B	15	10	1	
6	138	T	10	9	1	
7	147	T	10	4	3	
8	143	Y	10	8	3	
9	137	B	0	0	3	
10	126	B	8	7	3	
11	125	B	9	10	3	
12	115	T	16	7	3	
13	104	Y	0	0	3	
14	80	Y	0	0	3	
15	76	T	0	0	3	
16	504	T	10	6	2	
17	97	Y	0	0	2	
18	74	T	8	7	2	
19	47	B	13	10	2	
			7.68	**4.95**		**Total Average**

Table 6. Sire Breed Productivity of Grass Utilization Sows: Trial 3					
No. of Sows	**Sire Breed**	**Total Born Alive**	**Average Born Alive**	**Total # of Weaned Piglets**	**Average Weaned**
6	B	45	7.5	37	6.16
6	Y	35	5.83	24	4
7	T	66	9.42	33	4.71

APPENDIX C

PERCENTAGE OF TIME SPENT IN VARIOUS SECTIONS OF PADDOCK

Table 7. Comparison of minutes sows spent in paddock: Spring, Trial 1 (%)

Sow	Paddock BG*	Paddock MS	Paddock MQ	Paddock TF	Platform
1	47.88	1.83	0.55	0.63	49.08
2	1.29	34.26	0.46	21.42	42.5
3	35.39	3.21	1.75	34.64	25
4	44.41	0.54	2.17	1.9	50.95
5	5.26	90	0	0	4.73
6	49.34	7.99	6.63	30.5	5.5
Total Average	**30.59**	**22.97**	**1.93**	**14.85**	**29.63**

***BG= Bermudagrass, MS= Multispecies, MQ= Max Q Fescue, TF= Kentucky 31 Tall Fescue**

Table 8. Comparison of minutes sows spent in paddock: Summer to Fall, Trial 2 (%)

Sow	Paddock BG*	Paddock MS	Paddock MQ	Paddock TF	Platform
1	11.66	6.52	43.4	10.22	28.08
2	N/A	N/A	N/A	N/A	N/A
3	3.52	35.67	7.4	23.99	29.4
4	2.83	8.56	25.13	20.85	42.61
5	1.56	3.52	31.27	2.66	60.96
6	6.74	24.43	27.59	10.77	30.44
Total Average	5.26	15.74	26.95	13.69	38.29

***BG= Bermudagrass, MS= Multispecies, MQ= Max Q Fescue, TF= Kentucky 31 Tall Fescue**

Table 9. Comparison of minutes sows spent in paddock: Winter Trial 3 (%)					
Sow	**Paddock BG***	**Paddock MS**	**Paddock MQ**	**Paddock TF**	**Platform**
1	9.48	14.41	24.81	6.02	45.25
2	4.05	6.65	17.66	19.17	52.44
3	6.88	12.33	9.74	23.11	47.92
4	14.52	2.72	0	0	82.75
5	50.99	6.68	7.16	5.64	29.5
6	3.75	13.02	48.15	16.84	18.22
Total Average	14.95	9.3	17.92	11.8	46.01

***BG= Bermudagrass, MS= Multispecies, MQ= Max Q Fescue, TF= Kentucky 31 Tall Fescue**

Table 10. Summary of the percentage of time that each sow spent in paddocks for all three trials					
Sow	**Paddock BG***	**Paddock MS**	**Paddock MQ**	**Paddock TF**	**Platform**
1	19.42	6.25	32.25	7.71	34.35
2	3.07	16.47	11.54	19.97	48.92
3	15.57	21.56	5.53	27.83	29.48
4	8.46	6.83	18.68	15.51	50.49
5	16.84	9.24	22.19	3.42	48.27
6	16.57	17.85	26.99	16.98	21.59
Total Average	13.32	13.03	19.53	15.24	38.85

***BG= Bermudagrass, MS= Multispecies, MQ= Max Q Fescue, TF= Kentucky 31 Tall Fescue**

APPENDIX D

GRASS INTEGRITY BREAKDOWN BY TRIAL

Table 12. Grass Integrity: Post Summer to Fall Trial 2

Grass Score*	Paddock BG**	Paddock MS	Paddock MQ	Paddock TF	Total Average
0^{b}	12.07	0.097	2.31	10.31	6.19
1^{ab}	11.77	12.74	12.17	18.44	14.03
2^{a}	67.04	41.43	24.94	27.99	40.85
3^{a}	9.10	45.71	60.56	43.24	40.4

***Grass scores 0-3, 0= no cover, 1= partial cover, 2= moderate cover, 3= complete cover**
****BG= Bermudagrass, MS= Multispecies, MQ= Max Q Fescue, TF= Kentucky 31 Tall Fescue**
[a,b]Means having a letter in common are not significantly different at the 5% level of signifiance as indicated by Duncan's Multiple Range test ± 0.2

Table 13. Grass Integrity: Post Winter Trial 3

Grass Score*	Paddock BG**	Paddock MS	Paddock MQ	Paddock TF	Total Average
0^{a}	18.97	8.50	8.04	7.33	10.71
1^{a}	6.95	10.68	12.59	34.87	16.52
2^{a}	63.61	24.56	26.52	27.32	36
3^{a}	10.45	56.25	52.83	30.46	38.25

***Grass scores 0-3, 0= no cover, 1= partial cover, 2= moderate cover, 3= complete cover**
****BG= Bermudagrass, MS= Multispecies, MQ= Max Q Fescue, TF= Kentucky 31 Tall Fescue**
[a,b]Means having a letter in common are not significantly different at the 5% level of signifiance as indicated by Duncan's Multiple Range test ± 0.2

APPENDIX E

PIGS IN GROWTH PERFORMANCE TRIAL

Table 14. Growth Performance Study Participants

No.	Tag	Breed	Sex
1	985152005502001.00	T	M
2	985152005502003.00	Y	M
3	985152005502005.00	Y	M
4	985152005502006.00	T	M
5	985152005502007.00	Y	M
6	985152005502009.00	B	F
7	985152005502010.00	T	M
8	985152005502011.00	B	M
9	985152005502012.00	B	M
10	985152005502013.00	T	F
11	985152005502015.00	T	F
12	985152005502018.00	B	F
13	985152005502019.00	B	M
14	985152005502020.00	B	M
15	985152005502022.00	Y	M
16	985152005502023.00	B	M
17	985152005502024.00	T	F
18	985152005502025.00	T	M
19	985152005502051.00	B	F
20	985152005502052.00	B	F
21	985152005502053.00	Y	M
22	985152005502054.00	B	F
23	985152005502055.00	B	M
24	985152005502056.00	Y	F
25	985152005502058.00	T	M
26	985152005502059.00	B	M
27	985152005502060.00	B	F
28	985152005502061.00	B	F
29	985152005502062.00	T	F
30	985152005502063.00	B	F
31	985152005502064.00	B	F
32	985152005502065.00	B	F

33	985152005502066.00	B	F
34	985152005502067.00	B	F
35	985152005502068.00	B	F
36	985152005502070.00	T	F
37	985152005502071.00	B	F
38	985152005502072.00	B	M
39	985152005502074.00	B	M
40	985152005502075.00	T	F