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# Growth Of Post-Weaned Grazing Dairy Heifers When Evaluating The Effects Of Providing Shade Or Parasite Control

Mohammad W. Sahar  
*Purdue University*

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**PURDUE  
UNIVERSITY  
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Acceptance**

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By Mohammad W. Sahar

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Entitled  
GROWTH OF POST-WEANED GRAZING DAIRY HEIFERS WHEN EVALUATING  
THE EFFECTS OF PROVIDING SHADE OR PARASITE CONTROL

For the degree of Masters of Science

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Is approved by the final examining committee:

Dr. Tamilee D. Nennich \_\_\_\_\_

Dr. Michael M. Schutz \_\_\_\_\_

Dr. Michael K. Neary \_\_\_\_\_

Dr. Keith D. Johnson \_\_\_\_\_

Approved by Major Professor(s): Dr. Tamilee D. Nennich

---

Approved by: Dr. Alan G. Mathew

12/05/2014

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GROWTH OF POST-WEANED GRAZING DAIRY HEIFERS WHEN EVALUATING  
THE EFFECTS OF PROVIDING SHADE OR PARASITE CONTROL

A Thesis

Submitted to the Faculty

of

Purdue University

by

Mohammad W Sahar

In Partial Fulfillment of the

Requirements for the Degree

of

Master of Science

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Purdue University

West Lafayette, Indiana

To my family

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## LIST OF ABBREVIATIONS

AA	= Amino Acids
ADG	= Average Daily Gain
BCS	= Body Condition Score
BW	= Body Weight
CGM	= Corn Gluten Meal
CP	= Crude Protein
DDGS	= Dried Distiller Grains with Soluble
DE	= Digestible Energy
DM	= Dry Matter
DMI	= Dry Matter Intake
EBG	= Empty Body Weight Gain
EBW	= Empty Body Weight
EDTA	= Ethylenediaminetetraacetic Acid
FEC	= Fecal Egg Count
FM	= Fish Meal
GI	= Gastrointestinal
HG	= Heart Girth
HH	= Hip Height
HSBM	= Heat-treated Soybean Meal

HW	= Hip Width
IG-D	= Interval Grazed treated with Doramectin
IGF-1	= Insulin-Like Growth Factor-1
IGFBP-3	= Insulin-Like Growth Factor-Binding Protein-3
IG-I	= Interval Grazed treated with Ivermectin
LWG	= Live Weight Gain
ME	= Metabolic Energy
N	= Nitrogen
NEG	= Net Energy Requirement for Gain
NEM	= Net Energy Requirement for Maintenance
NSC	= Nonstructural Carbohydrates
P-D	= Permanent treated with Doramectin
P-I	= Permanent treated with Ivermectin
PUN	= Plasma Urea Nitrogen
PVC	= Polyvinyl Chloride
RDP	= Rumen Degradable Protein
RE	= Retained Energy
RT	= Rectal Temperature
RUP	= Rumen Undegradable Protein
SAS	= Statistical Analysis System
SBM	= Soybean Meal
THI	= Temperature-Humidity Index

W = Live Weight (kg)

WH = Wither Height

## ABSTRACT

Sahar, Mohammad W. M.S., Purdue University, December 2014. Growth of Post-Weaned Grazing Dairy Heifers when Evaluating the Effects of Providing Shade or Parasite Control. Major Professor: Tamilee Nennich.

Reduced heat stress and lower gastrointestinal parasite loads can increase growth rate in heifers, potentially reducing the age at first breeding and lowering the costs associated with raising replacement dairy heifers. Providing shade is a recommended practice for reducing heat stress of grazing animals and is considered important for their wellbeing and productivity. However, limited information is available on the growth performance of young grazing dairy heifers when they are provided shade. Likewise, numerous products exist to prevent gastrointestinal parasites in animals. The development of new anthelmintic products, such as LongRange<sup>®</sup> (eprinomectin), increase the need for research to help understand the effects of these products on growth rates and fecal egg counts (FEC) in post-weaned dairy heifers. Studies were conducted to evaluate management strategies for reducing heat stress and parasite loads in pre-pubertal grazing dairy heifers. The objectives of these studies were: Study 1) to determine the effects of shade on the growth performance of grazing Holstein dairy heifers throughout the summer months, and Study 2) to compare the effect of eprinomectin (LongRange<sup>®</sup>) and doramectin (Dectomax<sup>®</sup>) on weight gain, structural growth, and FEC of post-weaned dairy heifers grazed over the summer months.



In study 1, 76 (n = 44 in 2012 and n = 32 in 2013) Holstein heifers were randomly assigned to 1 of 4 groups according to BW ( $163.8 \pm 7.27$  kg,  $150.6 \pm 8.5$  d age). Groups were assigned to 1 of 2 treatments: no shade (NOSHADE) or 1.7 m<sup>2</sup> shade/heifer in 2012 and 2.3 m<sup>2</sup> shade/heifer in 2013 (SHADE). In study 2, 48 Holstein heifers were randomly assigned to 1 of 12 groups according to BW ( $169.5 \pm 8.5$  kg,  $149.8 \pm 13.8$  d of age) in 2014. Groups were assigned to 1 of 2 treatments: 1) treated with injectable eprinomectin (LongRange<sup>®</sup>) (LGR) or 2) treated with injectable doramectin (Dectomax<sup>®</sup>) and pyrethroid impregnated fly tags (DFT). Body weight (BW), hip height (HH), withers height (WH), hip width (HW), body condition score (BCS), and heart girth (HG) were measured every 4 weeks in all years. Rectal temperatures were collected every 4 weeks in study 1. Blood samples were collected for plasma urea nitrogen (PUN) analysis in all years. The duration of the studies were from May until September in years 2012 and 2013 and from May until August in year 2014. For study 2, individual fecal samples were collected for FEC and fly counts were determined. Data on water intake was collected in 2013 and 2014. Temperature and relative humidity were recorded using data loggers in all years. Data were analyzed using PROC MIXED in SAS. Growth data were analyzed as repeated records with paddock as the experimental unit.

Providing shade during the summer months or treating for gastrointestinal parasites did not change BW ( $P = 0.72$ ) and ( $P = 0.70$ ), respectively. The ADG was similar between the treatments in both studies. Skeletal measurements, including HH, WH, HW, and HG, were similar both in study 1 ( $P = 0.25$ ) and in study 2 ( $P = 0.34$ ). In study 1, when data were compared by year, BW and ADG were similar between years ( $P = 0.27$ ). Skeletal measurements including HH, WH, HG, and HW were different between

the years ( $P < 0.01$ ). The BCS and rectal temperatures were different between the years ( $P < 0.01$ ), but no treatment differences were detected ( $P < 0.85$ ). Temperature loggers recorded lower average ambient temperatures in SHADE compared to NOSHADE in both 2012 (32.1 and 33.1°C, respectively) and in 2013 (27.7 and 28.7°C, respectively) during mid-day (1200 to 1500 hr). Providing shade did not improve the growth performance of Holstein dairy heifers in study 1. In study 2, heifers receiving LGR had lower FEC ( $P = 0.02$ ). In contrast, heifers treated with DFT tended to be lower in count of horn flies ( $P = 0.08$ ). Water intake and face fly counts were similar between the treatments ( $P = 0.24$ ). The two parasite control products had similar effects on growth of post-weaned dairy heifers; however, the LGR treatment reduced FEC and the DFT treatment reduced horn flies.

Keywords: shade, heifers, growth, parasite control

## CHAPTER 1. REVIEW OF LITERATURE

### 1.1 Introduction

In the modern age of dairy farming, dairy farmers have the options to raise dairy heifers, purchase replacement heifers, or buy or lease dairy cows in order to replace animals to stay in business. Since purchased dairy cows often have an increased chance of having diseases (Sanders, 1990), many producers choose to retain their own replacements and either raise the animals themselves or have them raised by a custom heifer raiser. While raising dairy heifers, farmers have to invest capital in infrastructure, feed, labor and others items while receiving no returned benefits until the heifers become a part of the milking herd. Heinrichs (1993) states that raising replacement dairy heifers costs about 20% of the total expense of a dairy operation; thus, holding the second position following the feed costs in expenses of a dairy farm. Gabler et al. (2000) reported that the average daily cost of raising a replacement dairy heifer was \$1.55 (ranging from \$1.30 to \$1.77) and the average total cost was \$1124.06 (ranging from \$ 896.86 to \$1305.03). These costs accounted for various factors including feed, labor, reproduction, facilities, bedding, mortality, equipment, health, and interest that were

estimated from a survey of milking operations in Pennsylvania (Gabler et al. 2000). In addition, data from Wisconsin lists an average cost of \$2194 (ranging from \$1595 to \$2935) to raise one replacement Holstein dairy heifer from birth until freshening (Zwald et al., 2007). To reduce these costs, age of first calving can be decreased; thus, the farmer can save some feed and reduce some labor costs related to raising replacements. Therefore, heifer raisers need to focus on management strategies that will improve growth rates in order to reduce the age of first calving.

One of the potential problems with reducing the age of first calving is decreased milk production. Sejrnsen et al. (1997) reported that heifers receiving diets with a high plane of nutrition before puberty have decreased growth and development of the mammary gland; thus, negatively affecting future milk production. Likewise, Radcliff et al. (2000) reported a 14% reduction in milk production during first lactation when heifers received a high energy and CP diet compared to the heifers fed a lower CP and energy diet. Furthermore, Sejrnsen and Purup (1997) reported that rates of gain of more than 700 g/d can negatively affect mammary development and decrease milk production. Conversely, heifers had maximum milk production in their first lactation when gaining approximately 800 g/d (Zanton and Heinrichs, 2005).

When focusing on the goal of reducing the age at first calving to lower the costs of dairy replacement heifers, it is very important to decrease the age to puberty. Since the gestation period is fixed to  $280 \pm 2$  d, producers need to focus on providing higher growth rates to decrease the age of heifers at puberty (Hoffman and Funk, 1992). Similarly, Sejrnsen and Purup (1997) stated that as growth rates increase the age at puberty decreases. Sejrnsen and Purup (1997) further stated that it is important to understand the

relationship among mammary development, the initiation of puberty, and feeding level in order to have an ideal nutrition and management program for heifers. Patterson et al. (1992) also considered suitable feeding programs and appropriate management as means of accelerating growth of heifers in order to ensure that heifers have reached puberty early enough to allow them to be bred by 15 months of age so that the heifers will calve by 24 months of age. Radcliff et al. (1997) saw a 58 d reduction in age at puberty in heifers receiving a high energy, high CP diet while not affecting pelvic area, BW or WH. Gabler (2002) also emphasized that puberty was more related to BW than to age, concluding that age at puberty can be influenced by growth rate. Additionally, when Gardner et al. (1988) compared the calving age of heifers receiving high energy diets during early growth to the heifers on control diets, a difference of 2.4 months was seen in the age of first calving between the two treatments, with heifers calving at 22.2 months and 24.6 months, respectively. To conclude, producers who desire to reduce the costs of raising replacement heifers need to feed and manage heifers for high growth rates to reduce their age at puberty, allowing heifers to be bred sooner so they can enter the milking herd earlier.

## **1.2. Heifer Development and Nutrition**

Replacement heifers are one of the important factors to sustainable dairy farming and eventually producing good quality dairy products. These heifers usually do not return any profit until they enter the milking herd. Properly feeding the replacement heifers is essential to increase lifetime productivity of these heifers.

### **1.2.1. Water**

Water is considered one of the most important nutrients for animals. Providing a sufficient quantity of water is considered crucial for overall health and milk production (LeJeune, et al., 2001). According to (NRC 2001), the major factors influencing water intake are ambient temperature, milk production, dry matter intake, and the nature of the diet. To satisfy their water needs, animals use drinking water, water in feed and metabolic water (NRC 2001). Meyer et al. (2004) reported that the mean daily water intake for lactating dairy cows was 81.5 kg/cow ranging from 14.2 to 171.4 kg/cow. Furthermore, water intake increased by 1.52 kg/d in response to each degree of Celsius increase in ambient temperature (Meyer et al., 2004).

In grazing systems, it is crucial to have water sources close to grazing sites. Technological developments have made it easier to provide water sources in pastures. Water source can influence the area and degree of pasture use (Roath et al., 1982). In a study by Hart et al. (1993), animals that were grazed on either 24 ha or 207 ha pastures showed that the forage use was decreased on 207 ha pasture as the distance increased from the water source. Thus, having a close water source is crucial for the efficient use of pastures (Valentine, 1947).

### 1.2.2. Voluntary feed intake

Physiological mechanisms are involved in maintaining constant internal environments and controlling feed intake (Schmidt et al., 1988). Two major factors in controlling feed intake in ruminants are gut fill (distension) and the concentration of volatile fatty acids resulting from rumen fermentation, which increases during and after feeding (Schmidt et al., 1988). Furthermore, voluntary feed intake is also reduced when animals are near or above their critical temperatures, resulting in a negative influence on productivity (Beede et al., 1986). Lactating dairy cattle reduce their feed intake when the mean ambient temperature is above 25 to 27 °C (Beede et al., 1986). Additionally, diet composition can influence voluntary feed intake. Proportions of roughages in the diet are directly related to the reduction of DMI in lactating dairy cattle (NRC, 1981). The NRC (1981) states that a faster and greater reduction in DMI occurs while feeding feeds with a high level of roughage to lactating dairy cattle in an environment with rising environmental temperatures.

As mentioned above, climatic conditions can influence the DMI of cattle which is essential for high performance (Mader, 2006). Poor performance caused by high ambient temperatures results in huge economic losses. A study by St-Pierre et al. (2003) showed that ambient temperature causes annual losses of \$2.4 billion across livestock species and \$897 million in losses in the dairy industry in the United States. Heat-stress abatement strategies, such as providing shade structures, can be used to avoid reductions in DMI. Supporting this, Sullivan et al. (2011) showed DMI decreased for cattle with no shade when compared to cattle provided with shade structures.

### 1.2.3. Growth

Raising replacement dairy heifers is one of the main costs to producers in the dairy business. McCullough (1973) defined growth as “a correlated increase in mass of the body in definite intervals of time in a way characteristic of the species” which can be affected by three primary characteristics including: 1) breed of animal, 2) stage or time of maturity, and 3) the impact of the level of nutrition (McCullough, 1973). Preston (1966) reported that meeting energy requirements is very important for growing heifers; otherwise, meeting the requirements for protein possesses little meaning. The NRC (2001) stated that rumen degradable protein (RDP), which is required for microbial growth, and rumen undegradable protein (RUP), which supplements microbial protein, are two important components of protein needed to support the desired growth in growing animals. Furthermore, Merchen et al. (1992) suggested that the source of dietary protein has an effect on the performance of growing ruminants. The reason behind this suggestion is that the profile of amino acids absorbed by ruminants is influenced by the original source of protein. Conversely, when Mäntysaari et al. (1989) fed meat and bone meal, fish meal and an animal by-product blend as RUP sources to dairy heifers and compared them to heifers fed soybean meal (SBM), no changes were seen in growth, DMI, and feed efficiency.

Energy availability and the rate of protein synthesis play an important role in growth. The NRC (1996) reported protein synthesis rate as the first limiting factor as energy intake increases above maintenance requirements, with excess energy being stored as fat. As a result, the protein, water, and ash contents of the body are diluted even though they normally are deposited almost at constant ratios to each other depending on



age (NRC, 1996). Energy in the body is either retained as protein or fat and it can be calculated using the formula below.

$$RE = 0.0635 * EBW^{0.75} * EBG^{1.097}$$

Where RE stands for retained energy, EBW is abbreviated empty body weight and EBG denotes empty body weight gain (NRC, 1996). Furthermore, proportion of fat and protein can be calculated using following formulas (NRC, 1996).

$$\text{Proportion of fat} = 0.122 * RE - 0.146$$

$$\text{Proportion of protein} = 0.248 - 0.0264 * RE$$

Relationships among rate of gain, gain composition, and growth rate (percentage of mature weight) can be calculated using the formulas above. The amount of energy in the tissue is less than the energy required for growth in addition to maintenance. This is because energy is required for biochemical and physiological reactions such as metabolism, transportation of components, and new tissue synthesis (Miller, 1979). Gain composition can influence the amount of energy required per unit of growth. Smaller animals require less energy for each pound of gain compared to larger animals. In other words, as body size increases, the energy requirements for each unit of gain rise. Blaxter (1969) reported that there is less fat relative to protein, water, and minerals in the increased weight gain in small calves. Likewise, Miller (1979) states that gain composition in older animals contain higher amounts of fat and lesser amounts of protein, water, and minerals. Since more energy is needed to gain each pound of fat compared to other components, it can be concluded that the energy requirement for each unit of gain is directly proportional to the age of animal.

#### **1.2.4. Protein Metabolism**

Understanding protein digestion and utilization is essential as it is the second largest nutrient requirement of ruminants. Ruminants acquire their amino acids from two sources of feed protein: 1) protein that escapes ruminal degradation also referred to as RUP and 2) RDP which is utilized by rumen bacteria and then is available as microbial protein to the host animal (Asplund, 1994). These amino acids are then used for growth, milk production, hormone synthesis, tissue repair and synthesis, and other physiological functions (William et al., 1978). Some of the protein feeds, such as oil cakes and meals, animal protein (fish meal, blood meal, meat meal, etc.), corn gluten, distillers grain, field beans, and legumes are good sources of N for growing ruminants (Haresign et al., 1981). Additionally, non-protein nitrogen (i.e. urea) can also be utilized by ruminal microbes for amino acids synthesis (Haresign et al., 1981).

Minimum protein requirements in most livestock species are determined from the animal's need for essential amino acids and the nitrogen sources required to make nonessential amino acids (Tisch, 2006). However, in dairy and beef nutrition the protein level depends on the amount of energy in the diet. The ration should have enough protein to be able to support similar performance (gain or milk production) to what energy in the ration can support (Tisch, 2006). Growing animals should be fed diets with higher concentration of proteins compared to mature animals, because their DMI is relatively low as they have not yet reached mature body size (Tisch, 2006).

Dietary protein plays an important role in both the development of growing ruminants and their body composition. Dennis (2011) indicates that restriction of proteins at an early age in a low plane of nutrition can have negative effects on lean tissue

accretion when followed by high energy plane of nutrition. A study by Park et al. (1987) showed 1.8 times greater protein and growth efficiency in heifers that were gradually fed 15% below to 40% above the NRC requirements when compared to heifers in the control group receiving a diet with 12% CP. These outcomes indicate the significance of dietary protein in diets of growing heifers, especially in situations where there is compensatory growth and feed constraints.

Rumen undegradable protein (RUP) and energy level of the diet can affect growth and feed efficiency. Research by Bethard et al. (1997) showed improved dry matter efficiency for heifers fed high RUP and high energy diets. Heifers that received higher RUP diets showed higher efficiency of apparent total digestible nutrients (Bethard et al., 1997). Similarly, Tomlinson et al. (1997) showed an increased growth response as levels of RUP increased (31%, 43%, 50%, and 55%) as a % of CP. The ADG was directly proportional to RUP and increased linearly as RUP increased. Additionally, hip height was increased as RUP levels increased in the diet; however, increased levels of RUP had no effect on heart girth and wither height. In contrast, a study by Whitlock et al. (2002) reported that dietary protein did not influence weight gain, wither height, or carcass composition.

The source of protein in the diet might have an influence on growth and carcass characteristics. A study by Petit et al. (1991), where the investigators used 116 bull calves with an average weight of 73.8 kg and fed either soybean meal (SBM) or fish meal (FM) as the protein source, found that calves fed SBM had lower conversion efficiency of dry matter to weight gain when compared to calves fed FM. However, no differences were seen in daily gain and days to reach market weight (Petit et al., 1991). These results

indicate that feed efficiency was marginally improved by fractional substitution of SMB by FM.

The amino acids requirements for growth and maintenance in growing ruminants may be more than the supply of rumen microbial amino acids. This could be a potential reason for improvements in N utilization and gain due to the sources of dietary RUP (Koeln and Patterson, 1986). In contrast, Coomer et al. (1993) showed no differences in feed efficiency, ADG, or DMI in heifers when investigators looked at the effect of RUP in soybean meal (SBM) compared to corn gluten meal (CGM), heat-treated soybean meal, and the combination of CGM and HSBM on performance of growing heifers and steers, small intestine AA absorption, and diet digestibility. Steers fed CGM and HSBM had significantly higher absorption of AA when compared to those fed SBM (Coomer et al., 1993). In a study done by Cummins et al. (1982), researchers fed a 13% CP diet which contained 40%, 55%, or 70% RUP as a percentage of CP. The CP diet with 70% RUP resulted in the highest DM digestibility (69.5%), retained N (32.3 g/d), and apparent N digestibility (62.5%). Additionally, particle size negatively affected N digestibility, with a larger particle size having lower N digestibility (Cummins et al., 1982). The impact of dietary protein on mammary gland development is still uncertain. However, Radcliff et al. (1997) showed increased growth rate without detrimental effects on the mammary gland while feeding high protein and high energy diets to Holstein heifers. Yet, in a high plane of nutrition diet the concentration of insulin-like growth factor-binding protein-3 (IGFBP-3) goes up, which leads to more binding of insulin-like growth factor-1 (IGF-1), resulting in prohibition of proliferation of mammary gland tissue (Akers et al., 2000). Supporting the point, Weber et al. (2000) also reported that IGFBP-3 levels

increased in growing heifers receiving high planes of nutrition. Accelerated nutrition programs cause less secretory tissue development and more fat deposition in the mammary gland. Increased mammary gland size and decreased milk production was seen in prepubertal dairy heifers when Lammers et al. (1999) fed them to gain 1000 g/d compared to 700 g/d.

### **1.2.5. Energy Metabolism**

In order to perform work, energy is needed and the most important work for livestock is to maintain life. Excess energy is used for growth, production, and reproduction after maintenance requirements are met (David, 2006). Total energy in the tissue gained by an animal is equivalent to the net energy requirement for gain ( $NE_G$ ) for that animal (NRC, 1989). To calculate the  $NE_G$  for growing large-breed heifers, the following equation can be used.

$$NE_G \text{ (Mcal/day)} = (0.035 W^{0.75})(LWG^{1.119}) + LWG$$

In this equation,  $W$  refers to live weight (kg) and  $LWG$  denotes live weight gain (kg/day) (NRC, 1989).

Animals should be fed enough dietary energy to meet their maintenance and growth requirements. Shortages of dietary energy in ruminant animals for longer times can postpone puberty, and they have been found to increase the postpartum anestrus periods and interrupt the cyclicity in mature animals (Schillo, 1992). Yelich et al. (1995) reported an increase in BW and a younger age at puberty when heifers were fed to gain 1.36 kg/d compared to limit-fed and maintenance-fed heifers. Furthermore, increased amounts of carcass fat at puberty and higher body condition scores (BCS) were seen in

heifers fed high planes of nutrition compared to limit-fed and maintenance-fed heifers (Yelich et al., 1995). Also, Hoffman and Funk (1992) showed an inverse relationship between the age at puberty and growth rate. Consequently, age at first calving can be decreased by providing high growth rate diets to heifers and heifer raising costs can be potentially reduced. However, Sejrsen et al. (1997) reported that providing high plane of nutrition diets to heifers before puberty can decrease the growth and development of the mammary gland and negatively affect future milk production. Similarly, Radcliff et al. (2000) saw 14% reduction in milk production during first lactation of heifers receiving a high energy and CP diet compared to heifers fed a lower CP and energy diet. Gardner et al. (1977) reported no effect on milk production across multiple lactations and no changes in productive herd life when the heifers were fed 45% more digestible energy (DE). Furthermore, first estrus was seen 1.9 months earlier and growth rate was 38% faster than the counterpart heifers (Gardner et al., 1977).

As rates of gain that are too high may negatively influence mammary secretory tissue development, diets with rates of gain that are too low may also have a negative effect on mammary secretory tissue development. Harrison et al. (1983) fed for rates of gain of 1100 g/d (too high) or 570 g/d (too low) and saw a quadratic relationship between prepubertal mammary tissue and gain rate, suggesting that either case may negatively affect mammary gland development. Similarly, increased adipose tissue accumulation caused a 23% decrease in mammary gland tissue and 32% less mammary tissue DNA when Sejrsen et al. (1982) fed Danish heifers for 1218 g/d gain compared to 613 g/d gain. Furthermore, heifers fed for 613 g/d gain showed a 30% increase in parenchymal tissue in mammary glands with a 47% elevation in parenchymal DNA when compared to

heifers fed for 1218 g/d gain. Recently, Davis et al. (2008) fed prepubertal heifers high energy diets or low energy diets for 12 wk and showed that parenchymal tissue mass for heifers with high energy diets was reduced per 100 kg of carcass weight when compared to heifers fed low energy diets. From the studies above, it can be concluded that feeding diets for higher gain may negatively influence mammary tissue development and lower future milk production.

#### **1.2.6. Effects of Dietary Protein and Energy on Heifer Performance**

Efficient use of nutrients is key to reduce the costs of replacement dairy heifers and improve herd productivity. According to Preston (1966) it is very important to meet the energy requirements of young heifers; otherwise, meeting the requirements of protein will possess little importance. Several studies have looked at the individual effects of dietary protein and energy on growth of heifers before puberty; however, some studies have looked at effects of protein and energy on growth of prepubertal heifers together. For instance, Oldham (1984) reported that the overall pattern of nutrient utilization can be impacted in both the rumen and within the body by the interrelationship between dietary protein and energy.

In addition to reduced feed costs, prepubertal growth can be improved by maximizing nutrient utilization in heifers resulting in reduction of the overall cost of raising replacement heifers. As investigated by several scientists, nutrient utilization can be maximized by altering protein and energy ratios. In research by Gabler and Heinrichs (2003), heifers were fed diets for 800 g/d gain where dietary protein to energy ratios were altered and growth and feed efficiency of prepubertal heifers were assessed. Heifers had

increased height and improved feed efficiency when they received higher amounts of dietary protein (Gabler and Heinrich, 2003). These changes probably resulted from increased ratios of RDP to nonstructural carbohydrate (NSC) in the diet and improved RDP utilization (Gabler and Heinrichs, 2003). Likewise, Lammers and Heinrichs (2000) conducted a study on prepubertal dairy heifers to investigate impacts of varying ratios of dietary protein to energy on their feed efficiency, growth, and mammary gland development. Feed efficiency, ADG and growth rate were increased in heifers receiving high ratios of dietary protein to energy when compared to heifers receiving low ratios of dietary protein to energy (Lammers and Heinrichs, 2000).

### **1.3. Effect of Heat Stress on Feed Intake**

During hot weather, cattle commonly reduce feed intake as a way of coping with heat stress. Mitlöhner et al. (2001) conducted research using crossbred feedlot heifers and reported a 7% greater DMI in shaded heifers when compared to unshaded heifers (9.46 and 8.80 kg/d, respectively). Similarly, research by McGuire et al. (1991) found that Holstein cows fed *ad libitum* in a thermal comfort environment had 15.1 kg/d DMI, as compared to 11.1 kg/d DMI for cows fed *ad libitum* and placed in a thermal-stressed environment, and 11.5 kg/d DMI for cows fed a restricted DMI and housed in a thermal comfort environment. A review study by Morrison (1983) indicated that the reason for low performance of animals during heat stress was reduced DMI, which is mainly a consequence of elevated ambient temperature; specifically, when it exceeds 25°C. Furthermore, West (2003) also reported an inverse relationship between DMI and ambient temperature, temperature-humidity index, and rectal temperature. In other words,



as ambient temperature, temperature-humidity index, and rectal temperature increase, DMI will decrease (West, 2003). Additionally, West (2003) indicated that providing shade and other cooling strategies were useful in lowering an animal's body temperature, which in turn increased DMI. Also, Holter et al. (1997) conducted research on Holstein cows and reported a decrease in DMI due to heat stress, and they found that it decreased more in pluriparous cows than in primiparous cows (22% vs 6%, respectively).

Heat stress is one of the major reasons for low DMI (Holter et al., 1997), so protecting cows from direct and indirect solar radiation is a key to reduce heat stress and elevate DMI. West (2003) has stated that a well-designed shade structure could reduce heat loads by 30 to 50%. In research by Roman-Ponce et al. (1977), rectal temperatures were recorded as 38.9 and 39.4°C for shaded and nonshaded cows, respectively, indicating that providing shade can lower heat stress in animals and can result in increased DMI due to heat stress.

In order to keep animals cool while using shade structures, providing enough shade is important. In a review by Armstrong (1994), different types of shade structures and their benefits and deficiencies are discussed, and, based on climatic conditions (dry or wet), he suggested differing types of orientations for shade structures. In wet climates, shade structures should be north-south oriented to allow the sunlight to dry the ground if the floor is muddy, and each cow should have 2.4 to 5.6 m<sup>2</sup> under the shade structure (Armstrong, 1994). A less expensive option than using a solid roofing material for providing shade to cattle is to use shade cloth as a roof that can provide 30 to 90% shade. The most commonly used shade cloth provides 80% shade and is fabricated from polypropylene (Jones and Stallings, 1999).

### 1.3.1. Effect of Heat Stress on Water Intake

Water is considered vital in dairy cow nutrition. According to Murphy et al. (1983), water intake is directly related to DMI and milk production in lactating dairy cows. Water intake is also influenced by ambient temperature (Murphy et al., 1983). Furthermore, cool water increased milk production in lactating dairy cows by reducing their body temperature (West, 2003). In a study by Brosh et al. (1998), investigators looked at the combined effects of solar radiation, diet, and time of feeding. They protected or exposed growing heifers to solar radiation, fed either high or low metabolic energy (ME) diets, and provided feed either in the afternoon or morning during hot summer days (Brosh et al., 1998). Water intake was 335 mL/(kg<sup>0.75</sup>·d) for heifers exposed to solar radiation and fed a low ME diet, 368 mL/(kg<sup>0.75</sup>·d) for heifers protected from solar radiation and fed a low ME diet, 508 mL/(kg<sup>0.75</sup>·d) for heifers exposed to solar radiation and fed a high ME diet, and 461 mL/(kg<sup>0.75</sup>·d) for heifers protected from solar radiation and fed a high ME diet (Brosh et al., 1998). Significant differences were seen in water intake; however, these differences were not due to the effects of solar radiation and the researchers believed that heifers coped with the heat stress by increasing respiration rates (Brosh et al., 1998). Contrasting results were found by Johnson and Strack (1992) when shade was provided to sheep during the summer. In this study, shade did not affect water intake patterns in sheep. Furthermore, West (2003) reported an increase of 1.2 kg of water per each degree of C increase in ambient temperature for lactating cows. Based on these studies, it is understood that water intake increases as ambient temperatures increase, and it can be inferred that cattle can use water intake as a cooling strategy while heat stressed.

### **1.3.2. Effect of Shade on Body Temperature**

As defined by Sullivan et al. (2011), an animal gets heat stressed when total heat gain of the body exceeds the heat loss of the body. Increased body temperature is one of the primary concerns in dairy farming. Heat stressed cattle usually have lower feed intake, efficiency, and decreased growth rates (Hahn, 1999). Similarly, excessive heat stress due to higher ambient temperature, increased humidity, lower air movement, and elevated solar radiation can lower the productivity of animals and can sometimes even cause death (Lefcourt et al., 1996). To support the point, Busby and Loy (1997) reported a severe case of heat stress in western Iowa in 1995 caused the loss of 3750 cattle and resulted in \$2.8 million direct losses and \$28 million in production losses. These studies illustrated heat stress can be a severe problem in the livestock production industry. Due to the animal health concerns and economic losses resulting from heat stress, it is very important to find management strategies that can be used to help reduce heat stress.

While heat stress can cause great losses as previously mentioned, strategies exist which can help reduce heat stress in cattle. One of these strategies is providing shade to cattle, which can reduce radiant heat load by 30% or more (Bond et al. 1967). Blackshaw and Blackshaw (1994) considered solar radiation reduction as a potential way of coping with heat stress when ambient temperature, humidity, and solar radiation are high, and they further stated that shade can provide quick relief to heat stressed animals and improve performance. On the other hand, Mitlöhner et al. (2001) stated that shade has not always improved performance of cattle; however, it has consistently reduced respiration rates and body temperatures. Additionally, Bond et al. (1967) suggested that providing shade is an efficient means of lowering thermal radiation which helps animals regulate

their body temperature. Thus, providing shade is a strategy to help cattle cope with heat stress.

### **1.3.3. Signs of Heat Stress**

Heat stress in animals is the consequence of increased ambient temperature due to various factors when it surpasses the thermal zone of animals (Armstrong, 1994). In addition to increased ambient temperature, Sullivan et al. (2011) stated that metabolic heat is an additional factor contributing to heat stress. Brown-Brandl et al. (2005) conducted research using 8 crossbred steers (weighing  $294.7 \pm 10.8$  kg) in two treatments: shade access or no-shade access, and they reported respiration rate as the most appropriate indicator of heat stress. The reasons these investigators considered respiration rate as the most appropriate indicator of heat stress were that: 1) it was easy to monitor, 2) it does not need expensive equipment to measure, and 3) there is almost no lag associated with it (Brown-Brandl et al., 2005). According to work by Hahn (1998), the threshold temperature for increased respiration rate is set at 21 °C and as temperature exceeds 25 °C, animals will begin to undergo heat stress.

In addition to increased respiration rate, West (2003) identified reduced feed intake, seeking wind and shade, less activity, increased sweating, and elevated peripheral blood flow as further indications of heat stress in cows. Additionally, Lough et al. (1990) reported decreased milk production for heat stressed animals, with daily milk production of 23.9 kg, 22.2 kg, and 21.6 kg for cows in a thermal comfort environment fed *ad libitum*, cows in a thermal comfort environment fed a restricted diet (70% of *ad libitum*), and cows in a thermal stress environment fed *ad libitum*, respectively.

Slow growth may also be considered an additional sign of heat stress. In studies by Mitlöhner et al. (2001), scientists looked at performance of crossbred feedlot heifers while treating them with: 1) shade, 2) misting, 3) shade and misting, and 4) no shade or misting. Heifers receiving the shade treatment showed higher DMI and elevated ADG compared to the no shade treatment and reached desired BW 20 d earlier. In this research, heat stress negatively affected the productivity of beef heifers not provided shade, and misting was considered ineffective in decreasing heat stress (Mitlöhner et al., 2001).

Heat stress negatively affects the performance of animals (Mitlöhner et al., 2001) and lowers milk production (Lough et al., 1990). Furthermore, heat stress in severe cases can cause death of animals, resulting in extreme economic losses. Mechanisms should be developed to avoid heat stress and prevent lower performance, decreased production, and, in some cases, death of animals; thus, reducing financial losses and improving animal welfare. One of these mechanisms is providing shade to cattle, which can reduce radiant heat load by 30% or more (Bond et al. 1967). In addition to providing shade structures, barns with ventilation systems, fans, and sprinklers can help reduce heat stress in animals (West, 2003). Furthermore, genetic selection of animals against high ambient temperature may also be an option to overcome the issue of heat stress in animals (West, 2003). To support the later claim, Blackshaw and Blackshaw (1994) stated that the heat tolerance capacities of *Bos indicus* breeds and their crosses were better than *Bos taurus* breeds. Investigators listed the reasons for difference in heat regulating capacities of the mentioned breeds as; 1) differences in food and water consumption, 2) alterations in metabolic rates, 3) sweating rate, and 4) coat color and characteristics (Blackshaw and Blackshaw, 1994). Moreover, to maintain normal body temperature, *Bos taurus*

compared to *Bos indicus* typically evaporate more sweat due to elevated heat load at their skin (Blackshaw and Blackshaw, 1994). Therefore, detecting heat stress through elevated respiration rate (Brown-Brandl et al., 2005), reduced feed intake, seeking wind and shade, less activity, increased sweating, elevated peripheral blood flow (West, 2003), and decreased milk production (Lough et al., 1990) and utilizing mechanisms such as providing shade (Bond et al., 1967), barns with ventilation systems, that include fans, sprinklers, and genetic selection (West, 2003), can help animals to manage their body temperature and improve performance.

#### **1.3.4. Effects of Heat Stress on ADG, Weight Gain and Structural Growth**

As farms continue to become larger, even small improvements in ADG, growth, production or any other performance measure can have larger economic impacts. Therefore, conducting research about various factors, such as heat stress, that may affect the performance of animals is important. In a study by Mitlöhner et al., (2001), beef heifers receiving a shade treatment, when compared to those with no shade, increased their DMI by 7% and had an increase in ADG (1.6 and 1.4, kg/d; respectively) of 11.8%. Final BW also differed in the shade and no shade treatments (547 and 520, kg; respectively), with heifers in the shade treatment reaching their desired BW 20 d earlier (Mitlöhner et al., 2001). In Egypt, investigators conducted a study utilizing Friesian calves to look at the effects of heat stress during the Egyptian summer season and its control using a diaphoretic compound, in this case ammonium acetate, and water spray. An increase in gain (26.1%) was seen in calves treated with the diaphoretic compound and water spray even though the water spray was used only during the hottest time of the

day (Marai et al., 1995). Similarly, Colditz and Kellaway (1972) conducted research using Brahmans, Friesians, and Brahman × Friesian F1 crosses and exposed them to 17.2 and 37.8°C temperatures, with exposure to the high temperature resulting in decreased intakes of 12%, 17%, and 1.4%, respectively, for each breed. Additionally, Friesians had the least gain when in high temperatures and the greatest gain when in cold temperatures (Colditz and Kellaway, 1972). A study by Finch (1986) looked at the effect of coat color on heat stress where black *Bos indicus* steers had 58% and 16% greater inward flow of heat than white and brown steers; respectively. Similarly, dark coated *Bos taurus* cattle had an increased inward heat flow and severely decreased weight gains compared to those with white coat color (Finch, 1986). These results suggest that heat stress can negatively affect gains in some breeds more than others, and coat color can potentially play a role in how heat is handled by an animal.

Focusing on structural growth, a study by Gaughan et al. (2010) reported greater hip height in shaded cattle when investigators looked at the effect of shade on performance of feedlot steers. However, in a study by Krenek (2011) where Holstein bull calves were placed either indoors (temperature controlled) as a no heat stress environment or outdoors under a shaded barn as the heat stressed environment, weekly measurements on structural growth, including body length, wither height, hip width, hip height, and heart girth, resulted in no significant differences when comparing the two environments (Krenek, 2011). Further studies need to be conducted on heat stress and its effects on structural growth to have more precise information as to the effects of shade and other mitigation strategies.

### 1.3.5. Effect of Heat Stress on Feed Efficiency

Feed efficiency becomes more and more important as the number and size of farms increase. Given the scarce resources for farming and increasing needs of the population (as it grows) for meat and dairy products, feeding the world with quality products will become a big challenge in the next few decades. Therefore, it is important to produce more feed for animals per unit of area and increase the efficiency of conversion of feed to product from animals. Heat stress may be a factor affecting feed efficiency. A study by Mitlöhner et al. (2002) did not show statistical differences in gain:feed ratio or calculated  $NE_G$  and  $NE_M$  concentrations when investigators compared shade to no shade treatments. Similarly, another study by Mitlöhner et al. in (2001) also reported no differences in the gain:feed ratio, when heifers were subjected to; 1) shade, 2) misting, 3) shade and misting, and 4) no shade or misting treatments. In contrast, Marcillac et al. (2009) evaluated 40 Holstein heifers treated with either shade or water sprinklers during hot summer months and reported an 11% increase in feed efficiency for heifers receiving the shade treatment. Also, Coleman et al. (1996) provided supplemental shade to dairy calves reared in commercial hutches and found that calves in hutches placed under supplemental shade had similar ADG to the control group even though calves that received supplemental shade consumed less concentrates, indicating higher feed efficiency for calves under supplemental shade.

In 1983, Baccari et al. conducted an experiment using 5 month old Holstein heifers to measure the impact of heat stress on growth rate, plasma T3 (triiodothyronine), and the ability to compensate for lost gains following the heat stress period. Investigators reported reduced ratios of feed intake/body weight ( $w^{0.75}$ ) during the heat stress time,



indicating heat stress lowered feed efficiency (Baccari et al., 1983). Based on these studies, it can be inferred that heat stress negatively affected feed efficiency and that cooling strategies such as providing shade, as suggested by Marcillac et al. (2009) and Coleman et al. (1996), can help reduce heat stress and improve feed efficiency.

Protection of animals from heat stress is important in order to maximize productivity (Lefcourt et al., 1996). Cattle should be protected more during high temperatures than during low temperatures (Worstell et al., 1953). Growth rates, feed efficiency, and feed intake can be increased by reducing heat stress (Hahn, 1999). Heat stress, which is caused by direct solar radiation, increased ambient temperature and humidity, and lower air movement (Lefcourt et al., 1996), can be lessened by using heat stress reducing strategies such as providing shade, which is believed to reduce 30% or more of radiant heat load in cattle (Bond et al., 1967). Providing shade is considered to provide quick relief to heat stressed animals in times when solar radiation, ambient temperature, and humidity are high (Blackshaw and Blackshaw, 1994). Even though providing shade may not always improve performance of animals (Mitlöhner et al., 2001), providing it is recommended in order to help animals to regulate their body temperature (Bond et al., 1967).

#### **1.4. Effects of Parasite Control on Weight Gain, ADG, and Structural Growth**

Gain in body weight is the commonly used measure of benefits of parasite control, especially in pastured, young growing heifers. It is accepted worldwide among cattle producers, parasitologists, and veterinarians that gastrointestinal parasites have a role in reduced body weight gain (Hawkins, 1993). However, it is hard to define a time

frame for occurrence of these losses, and it is hard to determine the amount and type of parasite control needed in order to avoid losses and maximize profits.

Ciordia et al. (1984) looked at the efficacy of an anthelmintic (ivermectin) on performance of animals using 469 cows and calves that were either treated or not treated. Results showed that treated calves gained more than nontreated calves (Ciordia et al., 1984). Similarly, Schreiber et al. (1987) showed an increase in weight gain of calves treated with thiabendazole (an anthelmintic drug). In 1982, Ciordia et al. showed similar results when they put two herds (including cows and calves) on separate pastures and found that treating one herd with an anthelmintic (morantel tartrate) resulted in increased weight gain for both cows (28.8 kg) and calves (11.1 kg).

Improved weight gain resulting from parasite control has been frequently reported in stocker cattle or weaned calves on pasture due to the fact that this particular group is more prone to severe clinical parasitism (Hawkins, 1993). Various studies have reported improved weight gain due to utilization of various types of anthelmintics under different management conditions and in different geographic locations (Copeman and Hutchinson, 1980; Rickard et al., 1991; Taylor et al., 1985). Consequently, stocker cattle (older weaned calves) are consistently given more attention for parasite control throughout the world.

Several investigators have looked at the effect of parasite control on growth performance of both dairy and beef replacement heifers. Replacement dairy heifers are somewhat different than stockers due to concentrate supplementation in their diet as a supplement to grazing on pasture. In addition to improved weight gain in replacement heifers, reductions in the time necessary to reach puberty and breeding weights have been

reported by several investigators (Bradley et al., 1986; Fisher and MacNeill, 1982; Isles et al., 1985)

Parasite control can also influence ADG in cattle. A study by Stromberg et al. (1997) used a beef cow/calf herd to look at the impact of strategic anthelmintic treatment on growth and reproduction in midsummer. The group treated with fenbendazole had improved ADG when compared to the control group (0.83 vs 0.70 kg/d, respectively; Stromberg et al., 1997). Likewise, Leland et al. (1980) showed improved ADG when an extensive experiment was conducted using more than 1800 calves that were treated with formulations of levamisole, thiabendazole, and crufomate (ruelene). These numerous studies with positive results (Leland et al., 1980; Stromberg et al., 1997; Stuedemann et al., 1989) indicate that parasite control positively affects ADG in cattle.

Controlling gastrointestinal parasites may affect structural growth of heifers. A study by Mejía et al. (1999) showed no differences in wither height when Holstein heifers treated with ivermectin were compared to untreated naturally nematode-infected heifers. However, pelvic area was increased by 11 and 8% at the ages of 15 months and at 39 weeks, respectively (Mejía et al., 1999). Conversely, Robert et al. (2007) showed increased hip height gain in gastrointestinal resistant animals. Average hip height gain for resistant animals was 5.8 cm, which was numerically greater than average hip height gain for susceptible animals 4.8 cm (Robert et al., 2007). Furthermore, increased heart girth has been reported in heifers treated for gastrointestinal parasites. In a study by Ploeger et al. (1990) where half of each of 69 herds of first lactation heifers were treated with albendazole (anthelmintic) during winter housing, the treated heifers showed a 0.007 cm/d increase in heart girth circumference. Overall, the few studies (Mejía et al., 1999;

Ploeger et al., 1990; Robert et al., 2007) that looked at structural growth in response to parasite control showed only small numerical differences in structural growth as a result of gastrointestinal parasite control. Since only a few studies have reported data on effects of gastrointestinal parasite control on the structural growth of animals, further studies should be conducted in this area to be able to make a clear conclusion.

### **1.5. Effects of Parasite Control on Feed Efficiency**

Since resources are limited and needs for food across the globe are increasing each day, it is important to increase feed efficiency of animals to produce quality products with lesser feed inputs. Feed efficiency may be negatively affected by gastrointestinal parasites. Scientists have closely studied the relation of feed efficiency and gastrointestinal parasitism in feedlots, and both improved feed efficiency and weight gain have been shown (Bauck et al., 1989; Leland et al., 1980; Stewart et al., 1975). A 1975 study by Stewart et al. reported about a 6% advantage in feed efficiency in yearling steers, yearling heifers, and heifer calves when treated with anthelmintics (either levamisole or morantel tartrate) compared to the control group. In addition to the positive effects of anthelmintics on feed efficiency in heifers under feedlot conditions, treatment may also affect feed efficiency of animals under management conditions other than a feedlot, such as grazing cattle. Investigations have shown that replacement grazing heifers treated with anthelmintics and supplemented with corn significantly gained more weight when compared to heifers not dewormed, even though the same level of nutrition was available (Hawkins, 1993). These findings demonstrate that feed efficiency or feed conversion is negatively affected by presence of parasites in the gastrointestinal tract of

cattle; thus, to increase feed efficiency, cattle should be treated for gastrointestinal parasites.

### **1.6. Effects of Parasite Control on Fecal Egg Count**

As mentioned above, gastrointestinal parasites can negatively affect cattle performance and cause economic losses. In order to prevent these losses and maximize profit, cattle should be treated for parasites. The life cycle of a gastrointestinal nematode includes several stages; 1) cattle ingest the infective third stage larvae when grazing, 2) these larvae grow and develop into adult worms in the digestive tract, 3) worms in the digestive tract lay eggs, 4) eggs are excreted from the digestive tract in feces, and 5) eggs develop into larvae and are ingested by cattle again (Roeder et al., 2013). One potential way to break down this cycle and improve livestock performance is to treat animals with a dewormer to decrease the egg laying source and minimize the number of eggs excreted in feces on the pasture and lower the odds of infecting animals during grazing. In order for this to be effective, the dewormers need to be effective in lowering fecal egg counts (FEC). A study from Forbes et al. (2002) showed lower concentrations of eggs excreted in feces of treated calves (ranging from 0 to 250 eggs per gram with 73% of calves having less than 50 eggs per gram) when compared to fecal egg counts of the untreated control group (ranging from 0 to 650 eggs per gram and only 58% of calves having less than 50 eggs per gram). Likewise, research from Stewart et al. (1975) reported similar results of significantly lowered fecal egg counts when 64 yearling steers, 27 yearling heifers, and 40 heifer calves were either treated with morantel tartrate or levamisole HCL (both are anthelmintics) as compared to not being treated.

Additionally, it has also been reported that occurrence of gastrointestinal parasites and higher FEC are probably more related to increased forage consumption than to increased milk consumption in calves (Bogg et al., 1980), and it also is related to the concentrations of infective larvae on pasture (Forbes et al., 2002). Besides controlling the gastrointestinal parasites in an animal species, using strategic deworming programs may help reduce the larval loads of pastures. Stromberg and Averbeck (1999) suggested that using a long acting anthelmintic can help reduce larval loads of the pasture in addition to controlling internal parasites in animals. Therefore, deworming animals can indirectly reduce the risk of contamination of newly pastured animals due to reducing the larval loads of pasture.

### **1.7. Duration of Effect of Parasite Control Products**

The presence of parasites in the gastrointestinal system of animals have negative effects on weight gain, ADG, and feed efficiency. Treating animals with various anthelmintics have been researched and the results have shown that anthelmintics were effective in controlling gastrointestinal parasites (Forbes et al., 2002; Hawkins, 1993; Stromberg and Averbeck, 1999;). Consequently, increased weight gain, improved ADG and higher feed efficiency have been observed. There is a question about how long the gastrointestinal parasite control products control parasites and how frequently animals need to be dewormed in order to maintain increased weight gain, improved ADG, and higher feed efficiency.

To determine the duration of parasite control products, Williams et al. (1997) conducted research where investigators compared the effectiveness of two anthelmintic

products, either a doramectin injectable or an ivermectin injectable, using 66 crossbred beef calves that were 8 to 10 months of age and weighed 185 kg on average. Duration of activity of doramectin was 4 to 5 weeks and had an advantage over the duration of activity of ivermectin based on results of worm loads in interval grazed calves that received ivermectin and egg counts of permanently grazed calves receiving doramectin (Williams et al., 1997). In addition, eprinomectin is considered to protect animals from gastrointestinal parasites efficiently and for longer times (Forbes, 2013).

LongRange<sup>®</sup> is an injectable product designed to provide protection from gastrointestinal parasites in two peaks of activity that results in peaks in plasma concentrations of eprinomectin from injection until approximately d 25, with a second rise in plasma concentration occurring at approximately d 90 to 120 (Forbes, 2013). In addition to treating the existing infection, this profile of activity can also protect new infections until 100 to 150 d after administration (Forbes, 2013). Based on these studies, not all products provide protection from gastrointestinal parasites for the same amount of time.

### **1.8. Effects of Parasite Control on Fly Count and Fly Control**

Ectoparasite control is an important factor in livestock production. Each year, losses due to more than 50 species of ectoparasites exceed \$2.26 billion in livestock (Byford et al., 1992). On an individual level, some annual losses associated with the important ectoparasites are: approximately \$29.7 million for scabies and mange mites, \$38.7 million for mosquitoes, \$53.2 million for face fly, \$126.3 million for lice, \$398.9 million for ticks, \$607.8 million for stable flies, and \$730.3 million for horn flies (Byford

et al., 1992). Losses associated with ectoparasites can be the result of reduced milk production, lowered weight gain and decreased feed efficiency.

As the numbers above demonstrate, producers suffer huge economic losses due to ectoparasites each year. To prevent or minimize these economic losses, action to control them needs to be taken. One potential way of controlling them is providing ear tags impregnated with insecticide. Research by Ahrens (1977) used ear tags with 15% stirofos to control horn flies, which is historically considered the most important and economically damaging fly on cattle. The treatment controlled almost 100% of horn flies within two hours. The tags efficiently controlled flies for 12 to 14 wk due to slow release of the insecticide. Similarly, Williams and Westby (1980) used ear tags to control face flies and horn flies. Three types of ear tags were used that contained 5% or 10% permethrin and/or 1.5% decamethrin. All three types efficiently reduced horn flies by 95% and reduced face flies by less than 50% throughout the 13 wk period of study. Likewise, studies by Williams et al. (1981) used ear tags to control face flies and horn flies. In one of their studies (Williams et al., 1981), stirofos insecticide treated polyvinyl chloride (PVC) ear tags significantly reduced 79% of horn flies and 30% of face flies. Using coumaphos (Co-Ral) insecticide dust bags resulted in an 18% reduction of face flies and an 86% drop in the numbers of horn flies. In the second study by Williams et al. (1981), one-piece PVC treated ear tags impregnated with 5 and 10 % permethrin (Atroban) were used, with the 10% tag controlling 95% of horn flies and the 5% tag controlling 77% of horn flies. Furthermore, 49% of face flies were controlled with the 10% tags; however, the 5% tag did not reduce face flies significantly (Williams et al., 1981). Significant horn fly control (93%) and face fly control (34%) were seen in another



herd treated with coumaphos dust bags. In a third study by Williams et al. (1981), investigators looked at the effects of ear tags that were a two-piece design and were PVC-treated with 5 and 10% permethrin, and 5% permethrin-treated, two-piece ear tags with a 5% polyurethane matrix. Horn flies were reduced by 88, 83, 71 and 74% for 10% PVC-treated tag, 5% PVC-treated tag, 5% polyurethane matrix, and coumaphos dust bags, respectively, though face flies were not significantly reduced by any treatment (Williams et al., 1981). Additionally, the dollar return per each dollar spent ranged from \$2.16 to \$8.38 when Kunz et al. (1984) treated yearly stocking calves and their dams with fenvalerate (Ectrin<sup>®</sup>) ear tags. In summary, insecticide treated ear tags can be used to control horn flies and reduce face flies with a dollar return that is much higher compared to what is spent on other methods of controlling ectoparasites.

### **1.9. Eprinomectin Use in Farm Animals**

Eprinomectin is considered to efficiently protect animals from gastrointestinal parasites (Williams et al., 1999), and newer product formulations of eprinomectin can have parasite control for longer times (Forbes, 2013). LongRange<sup>®</sup>, a new eprinomectin product, provides protection from gastrointestinal parasites in two peaks of activity. Within a few days of injection, the first peak in plasma concentration of eprinomectin occurs. This peak gradually declines until approximately d 25 and then it stays constant until approximately d 70. Afterwards, a second peak is created due to a rise in plasma concentration at approximately d 90 to 120, and it declines until around d 160. In addition to treating the existing infection, this profile of activity can also protect new infections until 100 to 150 d after administration (Forbes, 2013).

To look at the effect of various anthelmintics, a study by Williams et al. (1999), treated animals with either doramectin, ivermectin, eprinomectin, and moxidectin or they were not treated. The anthelmintic activity of eprinomectin and moxidectin was shown to be greater than either the ivermectin or the control group based on reduced FEC. Additionally, egg counts of animals that were treated with eprinomectin stayed numerically lower than the egg counts of animals that were treated with doramectin and ivermectin throughout the study (Williams et al., 1999). Furthermore, eprinomectin efficacy has been tested in goats. In 2004, Cringoli et al. found that a single dose of eprinomectin treated lactating goats had reduced FEC by 90.0%, 91.6%, 89.4%, and 87.0% on d 7, 14, 21, and 28; respectively, when compared to the control group. In addition, goats treated with a double dose of eprinomectin had FEC that were reduced by 99.5%, 99.6%, 99.7%, and 96.7% on d 7, 14, 21, and 28, respectively, when compared to the control group (Cringoli et al., 2004), suggesting that a double dose in goats was required to have similar efficiency as compared to cattle.

### **1.10. Conclusion**

Following the feed costs, dairy farmers spend the second highest amount of money raising replacement heifers. One way to reduce these costs is to lower the age at puberty and breeding so the heifers are able to enter the milking herd sooner. Heat stress can reduce growth rates of heifers grazing on pasture. One way to reduce heat stress is to provide supplemental shade to grazing heifers. Studies have shown that heat stress occurs due to high ambient temperature, direct or indirect solar radiation, high humidity, and lower wind (Lefcourt et al., 1996). Strategies to reduce heat stress, including providing supplemental shade, has been recommended in order to improve animal comfort and production (Bond et al., 1967). Providing shade has been considered a quick relief for heat stressed animals, and it has been shown that shade lowers heat stress by 30% or more. Growth rates, feed efficiency, and feed intake can be increased by reducing heat stress (Hahn, 1999). Even though providing shade may not always improve performance of animals (Mitlöhner et al., 2001), providing it is recommended in order to help animals to regulate their body temperature (Bond et al., 1967). Little information is present about the effects of heat stress on young dairy heifers.

Additionally, gastrointestinal parasites can reduce the growth rate of grazing heifers (Ciordia et al., 1982). Several studies (Bauck et al., 1989; Leland et al., 1980) have reported slow growth and lower productivity of animals contaminated with gastrointestinal parasites. Several gastrointestinal parasite control products including eprinomectin and doramectin have been proven efficient in controlling these parasites (Williams et al., 1999). In addition to increased daily gain and improved feed efficiency, administration of gastrointestinal parasite control products to various species of animals,

including dairy and beef cattle, have shown significant reductions in FEC and a certain decrease in fly counts (Bauck et al., 1989; Leland et al., 1980; Williams et al., 1997).

Cattle should be protected from parasites in order to maximize growth rates and productivity. Consequently, it will help to lower the costs of raising replacement heifers by accelerating growth rates and increasing feed efficiency. Few studies have looked at young grazing dairy heifers so more information is needed.

Due to the importance of finding management strategies that improve the growth rates of dairy heifers, research studies were conducted to look at strategies for reducing heat stress and decreasing parasite loads in pre-pubertal grazing dairy heifers. The specific objectives of the research were: 1) to determine the effects of shade on the growth performance of grazing Holstein dairy heifers throughout the summer months, and 2) to compare the effect of eprinomectin (LongRange<sup>®</sup>) and doramectin (Dectomax<sup>®</sup>) on weight gain, structural growth, and FEC of post-weaned dairy heifers grazed over the summer months. These research studies focused on post-weaned dairy heifers, a stage of animal for which limited information is available. This research provides additional information about strategies to control heat stress and parasites and their effect on heifer growth.

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## CHAPTER 2. EFFECT OF SHADE ON GROWTH OF POST-WEANED GRAZING DAIRY HEIFERS

### 2.1 ABSTRACT

Shade is recommended for grazing animals and is considered important for their wellbeing and productivity. However, limited information is available on the growth performance of grazing dairy heifers when they are provided shade. The objective of this study was to determine the effects of shade on the growth performance of grazing Holstein dairy heifers throughout the summer months for 2 years. Seventy-six (44 in 2012 with  $164.8 \pm 9.8$  kg of BW,  $144.2 \pm 8.6$  d of age and 32 in 2013 with  $163.8 \pm 7.3$  kg of BW,  $150.6 \pm 8.5$  d of age) Holstein heifers were randomly assigned to 1 of 4 groups according to BW. Groups were assigned to 1 of 2 treatments: no shade (NOSHADE) or  $1.7 \text{ m}^2$  shade/heifer for 2012 and  $2.3 \text{ m}^2$  shade/heifer for 2013 (SHADE). Body weight, hip height (HH), withers height (WH), hip width (HW), body condition score (BCS), heart girth (HG), and rectal temperature were collected every 4 wks from May until September both years. Blood samples were collected for plasma urea nitrogen (PUN) analysis. Temperature and relative humidity were recorded hourly both in the pasture and under the shade structures using HOBO data loggers, and temperature-humidity indices (THI) were

calculated. Growth data were analyzed as repeated records with paddock as the experimental unit and environmental data were analyzed by location (pasture or under shade). Body weight at the end of the summer ( $P = 0.39$ ) and ADG ( $P > 0.66$ ) of heifers were similar between treatments. Skeletal measurements, including HH, WH, HW, and HG, were similar ( $P > 0.25$ ) between treatments both years. When comparing the data by year, BW and ADG were similar between years. There were differences ( $P < 0.01$ ) in structural growth (including HH, WH, HG, and HW), BCS and rectal temperatures between the years, but no treatment differences. Temperature loggers recorded lower average ambient temperatures in SHADE compared to NOSHADE in both 2012 (32.1 and 33.1°C, respectively) and in 2013 (27.7 and 28.7°C, respectively) during mid-day (1200 to 1500 hr). Providing shade did not improve the growth performance of Holstein dairy heifers in this study.

Keywords: Shade, Heifers, Growth

## 2.2. Introduction

Grazing dairy heifers provides the opportunity to utilize land to decrease feed costs while raising dairy heifers. One of the challenges with grazing dairy heifers during the summer months is that natural shade is often unavailable in pastures. To reduce heat stress in animals, providing shade is recommended (Davison, 1988). One of the common grazing systems is a rotational grazing system where animals are moved to a new pasture at least once a week, which can create additional challenges for providing shade for grazing animals. Previous research (Hahn, 1998; Lefcourt and Adams, 1996) demonstrated that exposure of animals to the combination of a higher solar load, increased ambient temperature, elevated humidity, and decreased air movement can surpass their coping capacity to dissipate body heat; therefore, lowering productivity and possibly even resulting in death in extreme situations.

Shade reduces mortality in harsh weather conditions (Busby and Loy, 1996) and improves the heat load of cattle (Brown-Brandl et al., 2005). Heat generated from solar radiation may affect animal productivity and well-being, and providing shade is recommended for their improvement (Mader and Davis, 2004).

As defined by Sullivan et al. (2011), an animal gets heat stressed when the total heat gain of the body exceeds the heat loss of the body. Beede and Collier (1986) have suggested three different management strategies to reduce heat stress. These strategies consist of modifying the physical environment (shading, cooling), developing genetically heat-tolerant breeds, and improved nutritional practices. Providing shade to cattle can reduce radiant heat load by 30% or more (Bond et al. 1967). Blackshaw and Blackshaw (1994) considered solar radiation reduction as a potential way to help animals cope with

heat stress when ambient temperature, humidity, and solar radiation are high; and they further stated that shade can provide a quick relief to heat-stressed animals and improve performance.

In study by Mitlöhner et al. (2001), heifers receiving a shade treatment, as compared to those with no shade, showed that ADG increased (1.60 vs 1.41, kg/d; respectively,  $P < 0.01$ ) by 11.8% and final BW also differed in shade and no shade treatments (547 vs 520 kg, respectively;  $P < 0.01$ ). In addition, heifers in the shade treatment reached their desired BW 20 d earlier (Mitlöhner et al., 2001). A study by Finch (1986) looked at the effect of coat color on heat stress where black *Bos indicus* steers had 58% and 16% greater inward flow of heat than white and brown steers, respectively. Similarly, dark coated *Bos taurus* cattle had an increased inward heat flow and severely decreased weight gains compared to those coated white (Finch, 1986). These results suggest that gain can be negatively affected in some breeds more than others by heat stress and cooling strategies, like providing shade, can help increase weight gains for animals in heat stress conditions (Mitlöhner et al., 2001).

When looking at structural growth, a study by Gaughan et al. (2010) reported greater hip height in shaded cattle when the investigator looked at the effect of shade on performance of feedlot steers. However, in a study by Krensek (2011), where Holstein bull calves were placed either indoors in a temperature controlled environment with no heat stress or outdoors under a shaded barn considered a heat stressed environment, measurements on structural growth including body length, wither height, hip width, hip height and heart girth were taken weekly and no significant differences were seen for any of these measurements (Krensek, 2011). Further studies need to be conducted on heat

stress and its effects on the structural growth of heifers for making more precise conclusions in this area.

Brown-Brandl et al. (2005) conducted research using eight crossbred steers (weighing  $294.7 \pm 10.8$  kg) in two treatments: shade access vs no-shade access, and reported lower respiration rate for the shade treatment. These researchers indicated that respiration rate was considered the most appropriate indicator of heat stress, because 1) it was easy to monitor, 2) it does not need expensive equipment to measure, and 3) there is almost no lag associated with it (Brown-Brandl et al., 2005). Furthermore, Roman-Ponce et al. (1977) also reported lower respiration rates for cows under shade when compared to no shade (54 and 82 breaths/min, respectively). According to work by Hahn (1998), the threshold temperature for increased respiration rate is set at 21 °C and as temperature exceeds 25 °C, animals will begin to undergo heat stress. In addition, water intake is influenced by ambient temperature (Murphy et al., 1983), and it will increase by 1.2 kg per each degree C increase in ambient temperature in lactating cows (West, 2003). Furthermore, cool water increased milk production in lactating dairy cows through reducing body temperature (West, 2003). Temperatures above the critical threshold due to high ambient temperature, temperature-humidity index, and increasing rectal temperature are associated with reduced efficiency of milk yield (West, 2003). Research by Roman-Ponce et al. (1977) reported a lower rectal temperature (38.9 compared to 39.4 °C) for cows in shade versus no shade environments, respectively. Additionally, cattle with shade had lower rectal temperatures, higher ruminal contractions, and increased milk yield compared to the ones with no shade (Collier et al., 1981). Overall, respiration rate, rectal temperatures, and water intake increases as heat stress increases in



animals, and shade has been shown to lower rectal temperature, indicating that it reduced heat stress in animals.

Providing shade may be beneficial to improve harsh environmental events when raising dairy heifers on pasture, and these improvements in conditions may reduce heat stress and lead to increased productivity and welfare.

### **2.3. Objective and Hypothesis**

The objective of this study was to determine the effect of shade structures on dairy heifer performance during the summer months when grazed on pasture. Our hypothesis was that heifers with shade will have better growth performance, lower respiration rates, and reduced rectal temperatures compared to heifers without shade during the high temperatures of summer months.

### **2.4. Material and Methods**

The experiments were conducted at the Southern Indiana Purdue Agricultural Center (SIPAC) near Dubois, Indiana, during the summer months of 2012 and 2013 using post-weaned Holstein heifers sourced from heifer raisers. All animal related procedures were conducted in compliance with approved protocols from the Purdue Animal Care and Use Committee (PACUC no. 1403001049). Seventy six (44 in 2012 with  $164.8 \pm 9.8$  kg of BW,  $144.2 \pm 8.6$  d of age and 32 in 2013 with  $163.8 \pm 7.3$  kg of BW,  $150.6 \pm 8.5$  d of age) Holstein heifers in groups of 11 in 2012 and 8 in 2013 were randomly assigned by body weight (**BW**) to 1 of 4 paddocks. The heifers, which had not grazed previously, were placed on the pasture 2 wk prior to start of the study for adjustment to grazing and

electrified wire fences. Each paddock was assigned to one of following treatments: 1) No shade (**NOSHADE**), and 2) 1.7 m<sup>2</sup> (2012) and 2.3 m<sup>2</sup> (2013) of shade per heifer (**SHADE**). The study was conducted from June 12 to September 4 in 2012 and from May 20 to September 9 in 2013. The study was one month longer in 2013 compared to 2012 as there was greater rainfall that resulted in improved pasture growth. Heifers were grazed on a pasture that was a mix of low-endophyte tall fescue (*Lolium arundinaceum l.*), white clover (*Trifolium repens l.*), and red clover (*Trifolium pratense l.*). Heifers were supplemented with a grain mix each year (Table 2.1) at the rate of 1.4% (DM basis) of their body weight. Heifers were rotated to a new paddock each week and the area of the pasture was adjusted according the plant growth of the pasture. One shade structure was provided in each SHADE paddock with the area of 18.4 m<sup>2</sup>, providing 1.7 m<sup>2</sup> and 2.3 m<sup>2</sup> shade to each heifer in 2012 and 2013, respectively. Shade cloth was knitted polyethylene fabric that provided 80% shade. Water was provided to each individual group both years. In year 2, water intake was measured by a water meter (Master Meter, Inc., Mansfield, TX) while not accounting for evaporation. Due to a leak in the water source in one paddock, the data of water consumption for one of the groups in the study was not used; therefore, only average values of water intake are provided and the data was not statistically analyzed. All measurements were collected at the beginning of the study and after each 4 wk. Measurements collected on heifers included body weight (**BW**), hip height (**HH**), wither height (**WH**), hip width (**HW**), heart girth (**HG**), rectal temperature (**RT**), and body condition score (**BCS**). Blood samples were collected from the jugular vein for plasma urea nitrogen (**PUN**) analysis. All measurements were collected while heifers were restrained in cattle chutes.

The BW was measured using a Tru-Test XR 3000 electronic scale (Tru-Test, Inc., Mineral Wells, TX), HH and WH were measured using an electronic laser measurer (BOSCH DLR130 Distance Measurer, Stuttgart, Germany), in a way that the distance between the ground and the top of the chute was measured first and then the distance between the heifer's back and top of the chute was subtracted from the total distance. The HW was measured using calipers, and HG was measured with a flexible measuring tape. The BCS was determined by two people at each time point using a scale of 1 to 5 (1 = emaciated, 5 = obese; Edmonson et al., 1989) and then the average of both values was used for analysis. Blood samples were collected via jugular venipuncture in EDTA test tubes (10 mL) and were stored on ice immediately after collecting the sample. Plasma was aspirated following centrifugation (3000 x g for 20 min) and frozen at  $-20^{\circ}\text{C}$  for later analysis. Plasma was analyzed for plasma urea N (PUN; procedure no. 0580; Stanbio Laboratory Inc., San Antonio, TX). Hide color was individually categorized as 0% being all or almost all white, 25% mostly white but having small black spots, 50% almost equally black and white, 75% mostly black but having some white present, and 100% almost all black. Due to the small number of heifers that were 0%, the number of heifers in the 0% and 25% groups were combined. The HOBO data loggers (Onset Computer Corp., Bourne, MA) were fixed outside of each paddock and beneath the shade cloth of both shade structures with a south and north orientation to measure the ambient temperature. Data loggers were fixed about 2 m from the ground surface under the shade structure and about 1 m from the ground surface outside of the shade structure.

Structural growth data were analyzed using the PROC MIXED procedure in SAS using repeated measures analysis. Fixed variables were treatment, month, year, and the

interaction of each of the variables. Pen was used as the statistical unit and pen within treatment was included as a random variable. Temperature data was also analyzed using PROC MIXED in SAS. Significance level was set as  $P \leq 0.05$  and trends were established at  $0.10 \geq P > 0.05$ .

## 2.5. Results and Discussion

Ambient temperature was measured during the course of study. The HOBO data loggers were used to record the ambient temperature once each hour. Data loggers were placed about 2 m from the ground under the shade structure and 1 m outside the shade structure with an orientation of north. As shown in Figure 2.1, there was a large difference in the midday (1200 to 1500) temperatures between years 2012 and 2013; however, temperatures between the treatments were not different during both years. In addition, a comparison of monthly average temperatures during 2012 and 2013 as compared to averages from 1994 to 2011 is provided in Figure 2.2.

In this research, ADG did not differ ( $P = 0.66$ ) between the treatments when shade was provided as a means of heat stress reduction. Similarly, BW ( $P = 0.72$ ) for heifers in SHADE and NOSHADE averaged 198.1 and 197.4 kg, respectively. At the age of the heifers in this study, the ratio of body area to the body mass is greater than in older and heavier animals, which means that heat dissipation is easier when animals are younger. This is a potential reason that heifers in this study did not show significant differences in BW and ADG between the treatments. In addition, when ADG and BW were assessed by year, differences were not found ( $P > 0.27$ ). There were no interactions between treatment and year for ADG and BW ( $P > 0.41$ ). In research by Mitlöhner et al. (2001),

investigators used heavier animals and found that final BW (547 vs 520, kg;  $P < 0.01$ ) and ADG (1.60 vs 1.41, kg/d;  $P < 0.01$ ) differed in shade and control treatments, respectively. In addition, heifers in the shade treatment reached desired BW 20 d earlier (Mitlöhner et al., 2001). Likewise, Colditz and Kellaway (1972) exposed Brahmans, Friesians, and Brahman  $\times$  Friesian F1 crosses to 17.2 and 37.8°C temperatures. When investigators compared the gains in cold and hot temperatures, Friesians had the least gain in high temperatures and the highest gain in cold temperatures (Colditz and Kellaway, 1972).

Skeletal measurements, as shown in Table 2.2, for HH, HW, and WH did not differ for SHADE or NOSHADE in the current study ( $P > 0.25$ ). Table 2.2 also summarizes the results for structural growth when the data from 2 years were compared. The HH, WH, HG, and HW were different between years ( $P < 0.01$ ; Figure 2.3). Interactions between treatment and year was different for WH ( $P = 0.05$ ), showed a trend for HW ( $P = 0.06$ ), and were similar for HH and HG ( $P > 0.43$ ). Similarly, the monthly changes in HH and HW were different between the years ( $P < 0.03$ ; Figure 2.4); however, changes in WH and HG were not different ( $P > 0.18$ ). Interaction between treatment and year was significant for the monthly change in HW ( $P = 0.02$ ), showed a trend in WH ( $P = 0.08$ ), and was similar for HH and HG ( $P > 0.22$ ). Similarly, in a study by Krenek (2011), where Holstein bull calves were placed either indoors (temperature controlled and considered a no heat stress environment) or outdoors under a shaded barn (considered a heat stressed environment), measurements taken on structural growth including body length, WH, HW, HH and HG did not differ when comparing the two environments (Krenek, 2011). In agreement with the results from Krenek (2011), HG measurements

were similar between the treatments ( $P = 0.61$ ) and different between the years ( $P < 0.01$ ; Figure 2.5) in the current study. However, a study by Gaughan et al. (2010) reported greater HH in shaded cattle when the investigator looked at the effect of shade on the performance of feedlot steers. Similarly, in research by Nardone et al. (2006), lower WH and narrower HW (35 and 29%, respectively) were found when they compared six female Holstein Friesian calves at the age of 5 mo that were exposed to hot conditions, with the control group housed under thermo-neutral conditions.

In the current study, rectal temperature did not differ between SHADE and NOSHADE ( $P = 0.85$ ) and averaged  $39.6^{\circ}\text{C}$  for SHADE and  $39.6^{\circ}\text{C}$  for NOSHADE treatments. Rectal temperature was compared between the years in the current study (Figure 2.6) and was different between the years ( $P < 0.01$ ). However, rectal temperature was not different when looking at the treatment by year interaction ( $P = 0.43$ ). The difference between the years could be explained by the differences in the ambient temperatures between 2012 and 2013. Ambient temperatures were higher in 2012, which led to increased rectal temperatures and more heat stress in animals. Providing shade has been shown to reduce heat loads in cattle, and it has been shown to reduce radiant heat load by 30% or more (Bond et al. 1967). Blackshaw and Blackshaw (1994) considered solar radiation reduction as a potential way of helping animals cope with heat stress and stated that shade can provide quick relief to heat stressed animals and improve performance. However, the measures collected during this study did not indicate that providing shade reduced heat stress of the heifers and no improvement in growth was seen.

Mitlöhner et al. (2001) stated that shade has not always improved performance of cattle; however, it has consistently reduced respiration rates. In contrast, the data collected on respiration rates in 2012 did not show reduced rates of respiration in this study ( $P = 0.55$ ). A positive correlation between respiration rate and both ambient temperature and THI was seen when looking at the Pearson correlation coefficients ( $P < 0.01$ ).

In this study, RT was not affected by either treatment or hide-color ( $P > 0.86$ ; Tables 2.2 and 2.3). However, there was a trend for an interaction between treatment and hide-color ( $P = 0.09$ ) averaging  $39.8^{\circ}\text{C}$  for SHADE and  $39.7^{\circ}\text{C}$  for NOSHADE. The effect of hide-color on BW was also assessed in the current study, though no differences in BW due to hide-color were detected ( $P = 0.34$ ), and there was not an interaction between treatment and hide-color ( $P = 0.82$ ). However, a study by Finch (1986) looked at the effect of coat color on heat stress where black *Bos indicus* steers had 58% and 16% greater inward flow of heat than white and brown steers; respectively. Similarly, dark coated *Bos taurus* cattle had an increased inward heat flow and severely decreased weight gains compared to those coated white (Finch, 1986).

Body condition scores (BCS) were similar between treatments and averaged 2.57 for both SHADE and NOSHADE ( $P = 0.90$ ). Furthermore, BCS were compared between the years and was statistically different between the years ( $P < 0.01$ ). The reason for the difference in years was most likely partially due to increased ambient temperatures in 2012 that elevated heat stress in heifers. Also, 2012 was a drought year, which lowered the availability of forage in the pastures. Both of these likely played a role in lowering the BCS of heifers in 2012 compared to 2013.

The simple average water intake in this study was 21.8 and 25.0 L/d per heifer in the SHADE and NOSHADE treatments, respectively. West (2003) stated that water is considered the most vital nutrient for dairy cattle and found water intake increased by 1.2 kg/°C<sup>-1</sup> increase in minimum ambient temperature in lactating cattle. Although statistics were not able to be analyzed on the water intake data, the averages indicate that heifers on the NOSHADE treatment may have consumed more water during the study. The additional water intake may have played a role in alleviating some of the heat stress of heifers that did not have access to shade.

In the current study, blood samples collected for PUN were similar and averaged 12.2 mg/dl for SHADE and 11.9 mg/dl for NOSHADE (P = 0.79) over the study. When PUN was assessed by year, it did not differ between the years (P = 0.26). Furthermore, no interaction between treatment and year was observed in this study (P = 0.72). However, in a study by Wheelock et al. (2010), increased PUN levels were seen in multiparous Holstein cows subjected to heat stress with *ad libitum* intake when compared to cows in thermoneutral conditions with *ad libitum* intake.

As mentioned in Materials and Methods section, the milder conditions of 2013 resulted in improved pasture conditions that allowed the heifers to be grazed for an additional month and allowed for another month of data collection (Table 2.4). The BW (P = 0.19), HH (P = 0.36), HG (P = 0.95), HW (P = 0.46), BCS (P = 0.47), and PUN (P = 0.37) were similar between the treatments at the end of the study; however, a trend was seen for an increase in WH (P = 0.08) for SHADE heifers. This extra month of data further confirmed that additional time on the treatment did not change the results that were seen at earlier time points.



## **2.6. Conclusions**

Supplemental shade did not significantly change the ADG or skeletal growth measurements of the dairy heifers in this study. Similarities in rectal temperatures and respiration rates indicated that effects of heat stress were not lowered in the SHADE treatment. Protection from direct solar radiation may potentially lower heat stress in grazing dairy heifers during the summer months; however, providing shade did not impact growth rates in this study.

## **2.7. Acknowledgements**

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Table 2.1: Grain mix composition in 2012 and 2013.

Item	2012	2013
Cracked corn, % of DM	35.1	36.2
Soybean meal, % of DM	15.8	11.2
DDGS <sup>a</sup> , % of DM	5.3	10.4
Grower mix <sup>b</sup> , % of DM	43.8	.
Cottonseed hulls, % of DM	.	19.4
Soyhulls, % of DM	.	12.5
Wheat midds, % of DM	.	8.6
Vitamin/Mineral, % of DM	.	1.7
<u>Nutrient Composition</u>		
DM, %	87.3	90.9
NEg, Mcal/kg	1.01	1.09
TDN, %	69.0	73.0
CP, %	18.5	18.0
NDF, %	37.5	40.5
ADF, %	25.4	24.5
Ca, %	0.76	0.82
P, %	0.52	0.69

<sup>a</sup>Dried distiller's grains with solubles.

<sup>b</sup>Commercial grain formulation from CPC Commodities, Fountain Run, KY.

Table 2.2: Growth, RT, and PUN data for NOSHADE and SHADE treatments.

Item	NOSHADE	SHADE	SE	P-value	P-value by year	P-value Trt*year
Average daily gain, kg/d	0.82	0.84	0.034	0.66	0.84	0.47
Body weight, kg						
Average	197.4	198.1	1.14	0.72	0.27	0.41
Initial	164.0	164.0	1.57	0.99		
Final	232.8	234.7	1.57	0.39		
Hip height, cm						
Average	115.4	115.4	0.24	0.92	0.01	0.43
Initial	110.5	110.4	0.30	0.79		
Final	120.0	120.1	0.30	0.85		
Change/mo, cm	3.21	3.35	0.137	0.50	0.03	0.73
Wither height, cm						
Average	109.8	110.2	0.17	0.25	0.04	0.05
Initial	105.2	105.0	0.24	0.61		
Final	114.3	114.9	0.25	0.11		
Change/mo, cm	3.04	3.03	0.110	0.16	0.18	0.08

Item	NOSHADE	SHADE	SE	P-value	P-value	P-value
					by year	Trt*year
Heart girth, cm						
Average	135.1	134.8	0.37	0.61	0.01	0.92
Initial	126.2	126.6	0.47	0.6		
Final	143.2	142.8	0.47	0.55		
Change/mo, cm	6.03	5.53	0.244	0.20	0.22	0.48
Hip width, cm						
Average	32.0	31.9	0.10	0.59	0.01	0.06
Initial	29.4	29.4	0.12	0.97		
Final	34.7	34.6	0.13	0.52		
Change/mo, cm	4.50	4.45	0.163	0.83	0.05	0.02
Rectal temperature, °C						
Average	39.6	39.6	0.03	0.85	0.01	0.43
Initial	39.2	39.1	0.05	0.74		
Final	39.7	39.8	0.05	0.09		
Body condition score, 1 to 5 scale						
Average	2.6	2.6	0.02	0.90	0.01	0.42
Initial	2.6	2.5	0.03	0.68		
Final	2.6	2.6	0.03	0.85		

Item	NOSHADE	SHADE	SE	P-value	P-value by year	P-value Trt*year
Plasma Urea Nitrogen, mg/dl						
Average	11.9	12.2	0.69	0.79	0.26	0.72
Initial	10.7	10.7	0.75	0.99		
Final	14.7	13.2	0.74	0.14		

Table 2.3. Hide-color effect on final BW and rectal temperature.

	25%	50%	75%	100%	
Item	Black	Black	Black	Black	P-value
Last RT <sup>1</sup> , °C	39.8	39.8	39.8	39.7	0.96
Last BW <sup>2</sup> , kg	227.6	232.9	235.6	235.2	0.34

<sup>1</sup>Body Weight, <sup>2</sup>Rectal Temperature

Table 2.4: Growth data collected at the end of the final month of the study in 2013.

Item	NOSHADE	SHADE	SE	P-value
Body weight, kg	257.5	263.0	2.90	0.19
Hip height, cm	122.2	123.2	0.59	0.36
Wither height , cm	116.8	118.8	0.43	0.08
Heart girth, cm	147.8	147.9	1.05	0.95
Hip width, cm	36.0	36.7	0.49	0.46
Body condition score, 1 to				
5 scale	2.7	2.8	0.04	0.47
Plasma urea nitrogen,				
mg/dl	10.9	12.3	0.86	0.37



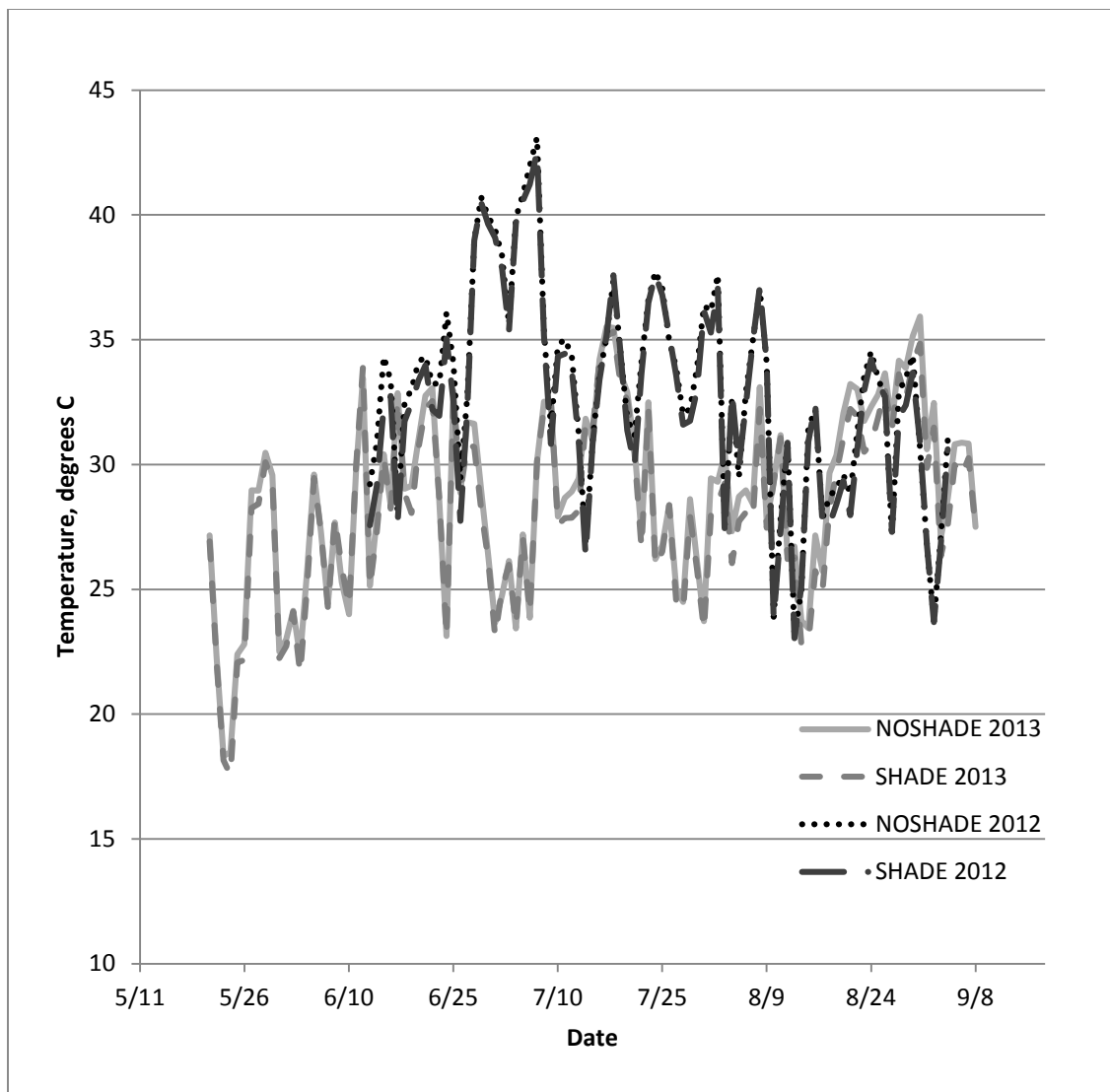


Figure 2.1. Ambient temperature under the NOSHADE and SHADE treatments in both years.

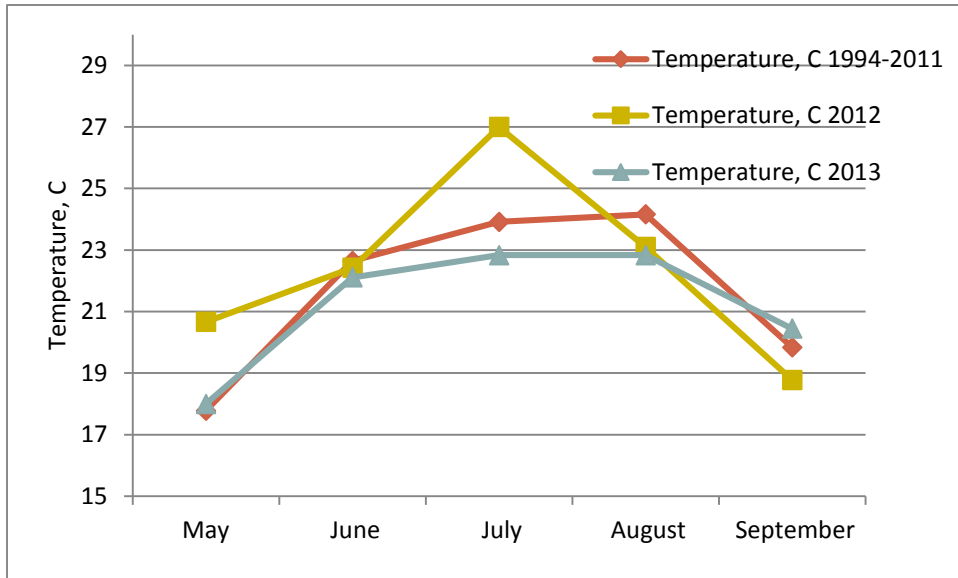


Figure 2.2. Average temperature for years 2012 and 2013 compared to average temperature of years 1994 to 2011.

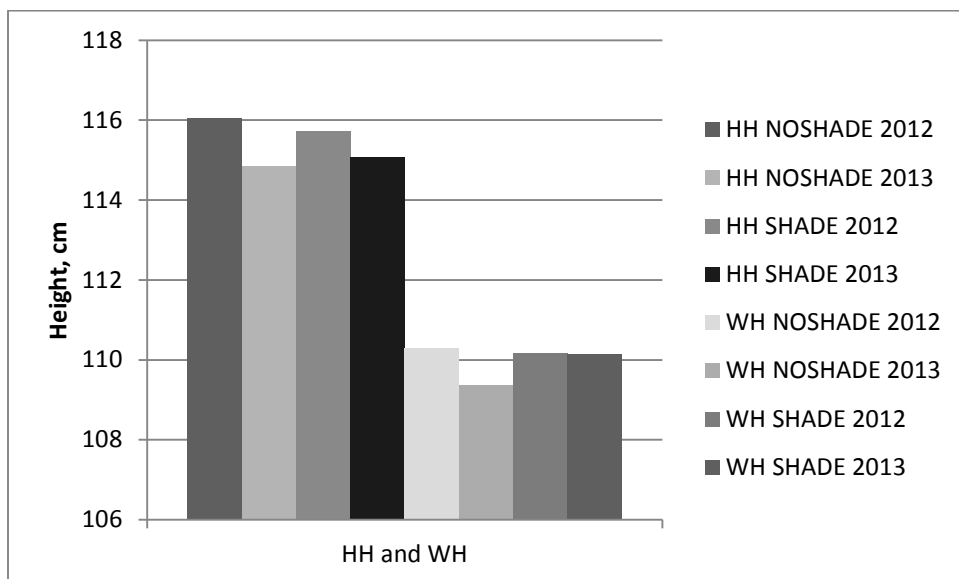


Figure 2.3. Hip height ( $P = 0.43$ ) and wither height ( $P = 0.05$ ) for each treatment in 2012 and 2013.

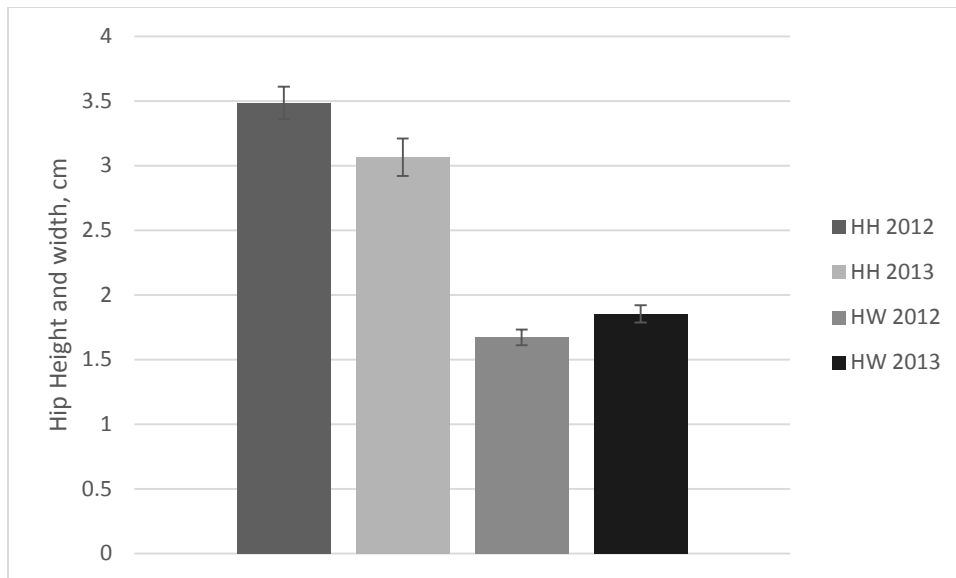


Figure 2.4. Changes hip height ( $P = 0.04$ ) and hip width ( $P = 0.03$ ) comparisons between years 2012 and 2013.

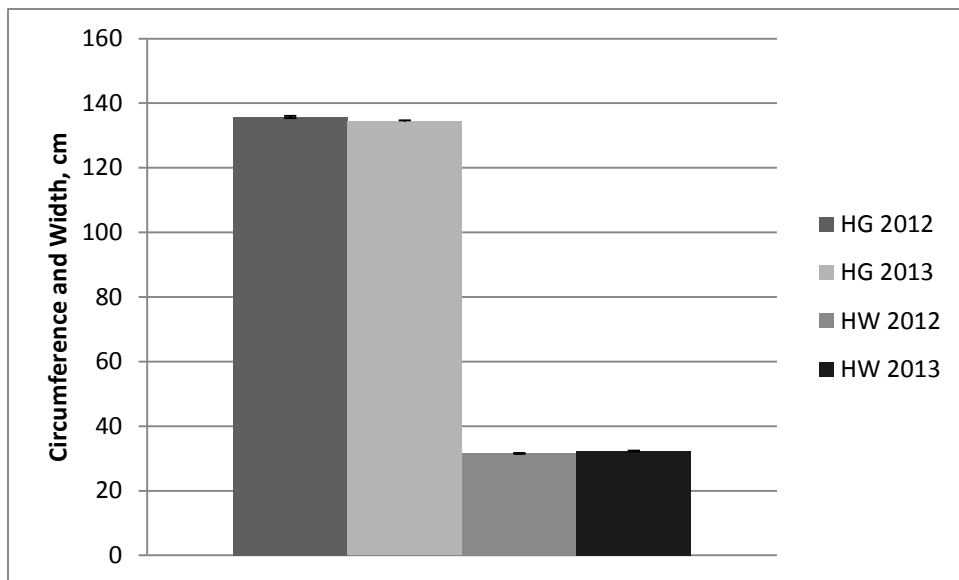


Figure 2.5. Heart girth ( $P < 0.01$ ) and hip width ( $P < 0.01$ ) comparisons between years 2012 and 2013.

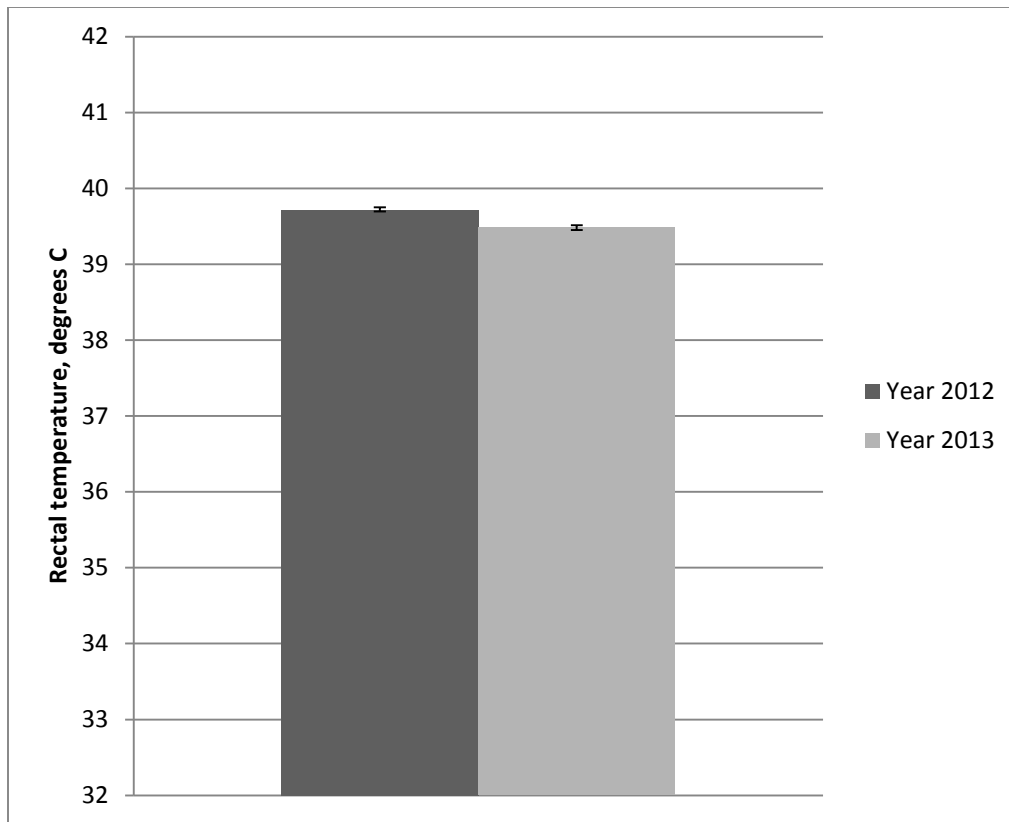


Figure 2.6. Rectal temperature comparison between the years ( $P < 0.01$ ).

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### **CHAPTER 3. COMPARISON OF THE IMPACT OF LONGRANGE® (EPRINOMECTIN) VERSUS DECTOMAX® (DORAMECTIN) AND FLY TAGS ON GROWTH OF POST-WEANED GRAZING DAIRY HEIFERS**

#### **3.1 ABSTRACT**

Treating animals with parasite control products has been effective in controlling gastrointestinal parasites and improving growth. However, limited information is available on gain and structural growth of young grazing dairy heifers when treated with different parasiticides during the summer months. The objective of this study was to compare the effects of LongRange® (eprinomectin) (LGR) against Dectomax® (doramectin) and pyrethroid impregnated fly tags (DFT) on gain, structural growth, and fecal egg counts (FEC) of grazing, post-weaned Holstein dairy heifers throughout the summer months. Forty-eight heifers were randomly assigned to 1 of 12 groups according to body weight (BW) ( $169.5 \pm 8.5$  kg of BW and  $149.8 \pm 13.8$  d of age). The groups were assigned to 1 of 2 treatments: 1) LGR or 2) DFT. Heifer groups were rotationally grazed on the same paddocks throughout the summer. The BW, hip height (HH), withers height (WH), hip width (HW), body condition score (BCS), heart girth (HG), blood samples, and fecal samples were collected every 4 wk from June until August 2014. Face flies (FF) and horn flies (HF) were counted twice per week. Water consumption for each paddock was recorded two times each week using

water meters. Temperature and relative humidity were recorded hourly using HOBO data loggers and temperature-humidity indices (THI) were calculated. Data were analyzed using PROC MIXED in SAS. Growth data were analyzed as repeated records using pen within treatment (as a random variable). Daily midday temperatures (1200 to 1500 h) averaged  $26.9 \pm 0.14$  °C during the study. The ADG was similar ( $P = 0.79$ ) between treatments (0.92 and 0.92 kg/d for LGR and DFT, respectively) with BW of heifers at the end of the study averaging 210.2 and 208.9 kg ( $P = 0.38$ ) for LGR and DFT, respectively. The HH and WH were similar between treatments ( $P = 0.61$ ) and averaged 117.4 cm and 112.3 cm, respectively, at the end of the study. The HG ( $P = 0.38$ ), HW ( $P = 0.34$ ), and BCS ( $P = 0.86$ ) were also similar between treatments. However, PUN values tended to be greater ( $P = 0.06$ ) for LGR heifers compared to DFT (12.7 and 11.4 mg/dl, respectively) at the end of the study. Water intakes averaged 18.8 L/d for DFT and 20.1 L/d for LGR ( $P = 0.67$ ). However, fecal egg count was lower ( $P = 0.02$ ) for heifers treated with LGR when compared to DFT (95.2 and 246.7 epg, respectively) and HF counts tended ( $P = 0.08$ ) to be lower for DFT treatment when compared to LGR (9.7 and 17.2 flies/heifer, respectively). The FF counts were similar between treatments ( $P = 0.24$ ). Treating post-weaned grazing Holstein dairy heifers with either LGR or DFT resulted in similar growth performance throughout the study. However, LGR efficiently reduced FEC throughout the study and DFT reduced the presence of horn flies.

### 3.2. Introduction

Treating with an anthelmintic to avoid gastrointestinal parasites can improve the growth performance and productivity of an animal (Hawkins, 1993). Gastrointestinal parasites negatively affect feed conversion to body mass and weight gain (Bauck et al., 1989; Leland et al., 1980). Therefore, protecting heifers against gastrointestinal parasites is important to avoid decreases in feed efficiency and weight gain. Various anthelmintic products such as eprinomectin, doramectin, levamisole, morantel tartrate and others are available to cattle producers to control gastrointestinal parasites. A study by Stewart et al. (1975) reported about a 6% advantage in feed efficiency in yearling steers, yearling heifers, and heifer calves when treated with anthelmintics (either levamisole or morantel tartrate) and compared to a control (not treated with an anthelmintic) group under feedlot conditions. Additionally, research has shown that grazing replacement heifers, treated with an anthelmintic and supplemented with corn, significantly gained more weight when compared to heifers not dewormed even though the same level of nutrition was available (Hawkins, 1993).

Improved weight gain resulting from parasite control has been frequently reported in stocker cattle or weaned calves on pasture due to the fact that this particular group of animals are more prone to severe clinical parasitism (Hawkins, 1993). Various studies have reported improved weight gain due to utilization of various anthelmintics under different management conditions and in different geographic locations (Copeman and Hutchinson, 1980; Rickard et al., 1991; Taylor et al., 1985). Consequently, this particular group of animals is consistently given more attention for parasite control. Additionally, several investigators have looked at the effect of parasite control on growth performance

of both dairy and beef replacement heifers (Fisher and Mac Neill, 1982; Isles et al., 1985). In addition to improved weight gain in replacement heifers, reduction in time necessary to reach puberty and breeding weights has been reported (Bradley et al., 1986; Fisher and MacNeill, 1982; Isles et al., 1985).

Based on these studies, it can be concluded that treating heifers for gastrointestinal parasites can help improve feed efficiency, weight gain and performance of heifers. Additionally, improved feed efficiency due to controlling gastrointestinal parasites (Stewart et al., 1975) allow farmers to grow more heifers per amount of feed or grow an animal with lesser feed while not affecting growth negatively and, therefore, are able to reduce feed costs of growing heifers.

Eprinomectin has been found to protect animals from gastrointestinal parasites efficiently and for longer times (Forbes, 2013). Recently, a new product containing eprinomectin, sold under the trade name LongRange<sup>®</sup>, was developed. LongRange<sup>®</sup> is an injectable product designed to provide protection from gastrointestinal parasites in two peaks of activity that results in peaks in plasma concentrations of eprinomectin from injection until approximately d 25, with a second rise in plasma concentrations occurring at approximately d 90 to 120 (Forbes, 2013). In addition to treating the existing infection, this profile of activity can also protect new infections until 100 to 150 d after administration (Forbes, 2013). Additionally, in a comparison study by Williams et al. (1999), animals treated with eprinomectin had lower egg counts than animals treated with doramectin, ivermectin, or the control group.

Dectomax<sup>®</sup> injectable can be administered at the rate of 1ml/10 kg of BW and has been shown to be effective in eliminating gastrointestinal parasites (Hale et al., 2010).

Heifers treated with Dectomax<sup>®</sup> or ivermectin had higher weight gains, greater pregnancy rate, greater calf birth weights, and better body condition scores compared to untreated heifers (Loyacano et al., 2000). Additionally, Dectomax<sup>®</sup> was detected in plasma between 1 h and 70 d after treatment (Lanusse et al., 1997). Based on these studies, it can be concluded that treating animals with Dectomax<sup>®</sup> can improve their growth and productivity and can protect animals up to 70 d after administration.

### **3.3. Objective and Hypothesis**

The objective of this study was to compare the effect of either LongRange<sup>®</sup> (eprinomectin) or Dectomax<sup>®</sup> (doramectin) on ADG, structural growth and FEC of post-weaned dairy heifers over the summer months when grazed on pasture. Our hypothesis was that heifers treated with LongRange<sup>®</sup> would have better growth and lower FEC compared to heifers treated with Dectomax<sup>®</sup>.

### **3.4. Materials and Methods**

The experiment was conducted at the Southern Indiana Purdue Agricultural Center (SIPAC) near Dubois, Indiana, from June to August of 2014 using post-weaned Holstein heifers sourced from heifer raisers. All animal related procedures were conducted in compliance with approved protocols from the Purdue Animal Care and Use Committee (PACUC no. 1403001049). Forty-eight Holstein heifers ( $169.5 \pm 8.5$  kg of BW and  $149.8 \pm 13.8$  d of age) were stratified by body weight (BW) and randomly assigned to groups of 4 heifers and placed in 1 of 12 paddocks. One heifer was removed from the study on Jun 17, 2014 due an illness not related to treatment. The heifers, which

had not grazed previously, were placed on pasture 2 wk prior to start of the study to get them adjusted to grazing and electrified wire fences. Each paddock was assigned to one of following treatments: 1) LongRange<sup>®</sup> injectable (**LGR**) and 2) Dectomax<sup>®</sup> (doramectin) injectable and fly tags that were impregnated with pyrethroid (**DFT**). Eprinomectin and doramectin were injected as subcutaneous injections in front of the shoulder at the dose rate of 1mL/50 kg BW on June, 2<sup>nd</sup> 2014. Heifers were grazed on a pasture that was a mix of low endophyte tall fescue (*Lolium arundinaceum l.*), white clover (*Trifolium repens l.*), and red clover (*Trifolium pretense l.*). Heifers were supplemented with a grain mix (Table 3.1) at the rate of 1.7% (DM basis) of their starting BW. Heifers were rotated every 2 wk to a different paddock and the area of the pasture was set according to plant growth on the pasture to provide *ad libitum* intake of forage. Individual heifer groups remained on the same two whole paddocks throughout the study. Water was provided to all twelve groups and water intake (not accounting for evaporation) was measured twice a week by multi-jet water meters (Master Meter, Inc., Mansfield, TX). All measurements were collected at the beginning of the study and after each 4 wk, with the final measurements collected on d 84. Measurements collected on the heifers included BW, hip height (**HH**), wither height (**WH**), hip width (**HW**), heart girth (**HG**) and body condition score (**BCS**). Blood samples were taken every four wks from the jugular vein for plasma urea nitrogen (**PUN**) analysis. Fresh fecal samples were manually collected for fecal egg counts (**FEC**) every four wks. Face flies and horn flies were counted twice a week by a trained observer.

The BW was measured using a Tru-Test XR 3000 electronic scale (Tru-Test, Inc., Mineral Wells, TX), HH and WH were measured using an electronic laser measurer

(BOSCH DLR130 Distance Measurer, Stuttgart, Germany), in a way that the distance between the ground and the top of the chute was measured first and then the distance between the heifer's back and top of the chute was subtracted from the total distance. The HW was measured using a wooden caliper, and HG was measured with a flexible measuring tape. The BCS was determined by two people at each time point using a scale of 1 to 5 (1 = emaciated, 5 = obese; Edmonson et al., 1989) and then the average of both scores were used for analysis. Blood samples were taken via jugular venipuncture in blood tubes containing EDTA (10 mL) and were stored on ice immediately after collecting the sample. Plasma was aspirated following centrifugation (3000 x g for 20 min) and frozen at -20 °C for later analysis. Plasma was analyzed for plasma urea N (PUN; procedure no. 0580; Stanbio Laboratory Inc., San Antonio, TX). Fecal samples were collected in plastic bags and placed in a cooler with ice immediately after collection, making sure samples did not directly contact the ice. Samples from twelve heifers within each treatment were composited and sent to the University of Georgia laboratory (Merial ID# 7-14-120) for coproculture analysis (culture of feces for the purpose of hatching parasite eggs and obtaining larvae for morphological identification) each time samples were collected (Dinaburg, 1942). The FEC was performed using both the modified Wisconsin (**MW**) centrifugal floatation technique (Ito, 1980) and the McMaster method (**MM**) (a quick method for determining the number of nematode eggs (as the eggs are floated free of debris before counting) per gram of feces in order to estimate the worm burden in an animal using a special counting chamber (Whitlock, 1948). For the WM, eggs counted were multiplied by 5 to determine eggs per gram (epg) and for the MM, eggs counted were multiplied by 25.



Ambient temperature and humidity were recorded every hour using HOBO data loggers (Onset Computer Corp., Bourne, MA). The HOBO data loggers were fixed outside near the paddocks and temperature and humidity measurements were determined about 1 m from the ground surface.

Structural growth data were analyzed using PROC MIXED procedure in SAS using repeated measures analysis. Fixed variables were treatment, month, and treatment by month. Pen was used as the statistical unit and pen within treatment was included as a random variable. The FEC and fly counts data were transformed [ $\log(n + 1)$ ] and then analyzed as repeated measures using PROC MIXED in SAS; however, means are reported from non-transformed data. Temperature data were also analyzed using PROC MIXED in SAS. Significance level was set as  $P \leq 0.05$  and trends were established at  $0.10 \geq P > 0.05$ .

### **3.5. Results and Discussion**

In this study, the ADG of heifers were similar between treatments with heifers gaining an average of 0.92 kg/d (Table 3.2). Previously conducted studies (Leland et al., 1980; Stromberg et al., 1997; Stuedemann et al., 1989) have reported increased ADG when treated animals were compared with control groups; however, in the current study, two gastrointestinal parasites control products were compared and, due to the limitation of resources, a regular control group was not included. A study by Stromberg et al. (1997) looked at the impact of strategic anthelmintic treatment on growth during midsummer and found improved ADG for the group treated with fenbendazole when compared to the control group (0.83 vs 0.70 kg/d, respectively). Likewise, Leland et al.

(1980) showed improved ADG for calves treated with formulations of levamisole, thiabendazole, and crufomate (ruelene) compared to the control. However, daily gain was similar in a study when doramectin and ivermectin injectable were compared to each other and an ivermectin pour-on treated group (Ballweber et al., 1997).

The BW of the heifers were similar ( $P = 0.70$ ) at the end of this study (Table 3.2). In contrast, Ciordia et al. (1984) showed improved gain for calves treated with ivermectin when compared to a control group. Similarly, increased weight gain has been shown for both cows and calves, with average increases of 28.8 and 11.1 kg, respectively, when a herd of beef cows was treated with an anthelmintic (morantel tartrate) (Ciordia et al., 1982). In a study by Williams et al. (1999), anthelmintics, including doramectin, ivermectin, eprinomectin, and moxidectin, were compared to each other and a control group. No significant differences between weights were found when calves treated with these products were compared to each other; however, weight of calves treated with each of these products other than ivermectin were different than the control group (Williams et al., 1999). Similarly, weight gains were similar in all groups of zebu animals treated with a double dose of oxfendazole 4 d prior to the start of the study and then groups of animals were treated with either abamectin, doramectin, ivermectin, moxidectin, and albendazole and no differences were seen in weight gains when the groups of animals treated with these products were compared to each other (Meeus et al., 1997).

Additionally, controlling gastrointestinal parasites may also effect structural growth of heifers. A study by Mejía et al. (1999) showed no differences in wither height when Holstein heifers were treated with ivermectin; however, their pelvic area was increased by 11% at 15 months of age and 8% at 39 weeks compared to untreated heifers

(Mejía et al., 1999). In the current study, HH, WH, HG, and HW were measured throughout the study, though no differences were seen ( $P \geq 0.32$ ). However, Li et al. (2007) showed increased HH gains in gastrointestinal resistant animals, with average HH gains for resistant animals of 5.8 cm compared to average HH gains of 4.8 cm for susceptible animals. Furthermore, increased HG has been reported by Ploeger et al. (1990) in heifers treated with albendazole for gastrointestinal parasite control treated heifers having 0.007 cm/d greater HG circumference as compared to control animals. Nevertheless, our current study did not show significant differences in HG when the two treatments were compared. The similarities in structural growth between the treatments in the current study were not unexpected since both treatment groups were treated with an anthelmintic. Since relatively few studies have reported data on effects of gastrointestinal parasite control on structural growth of animals, further studies in this area are needed to evaluate the true impacts of parasite control on structural growth.

When evaluating the PUN of heifers in this study, heifers treated with LGR tended ( $P = 0.06$ ) to have a greater PUN at the end of the study than heifers treated with DFT, with values of 12.7 mg/dl and 11.4 mg/dl, respectively. However, in a study by Fisher and MacNeill (1982), investigators did not see any change in blood urea nitrogen for heifers treated with an anthelmintic compared to the control group. The reason for the increased PUN for the LGR heifers in this study is not known.

Water consumption was measured in this study and was similar between treatments ( $P = 0.67$ ) averaging 20.1 and 18.8 L/d per heifer for heifers treated with LGR or DFT, respectively. Water consumption of grazing dairy heifers treated with an

anthelmintic has not been previously reported, and very little information is available on water consumption of dairy heifers.

### **3.5.1. Fecal Egg Counts (FEC) and Fly Counts**

Gastrointestinal parasites can negatively affect cattle performance; and thus, cause economic losses (Hawkins, 1993). One potential way to break the parasite cycle and improve livestock performance is to treat animals with a dewormer to decrease the egg laying source and minimize the number of eggs excreted in feces, lowering the future odds of infecting animals during grazing. In order for this to be effective, the dewormers need to be effective in lowering fecal egg counts (FEC). In the current study, FEC were determined using both the MW and MM methods. The FEC based on the MW method ( $P = 0.04$ ) and MM method ( $P = 0.02$ ) were lower in heifers treated with LGR when compared to heifers treated with DFT over the entire study (Figure 3.1). These results agree with the findings of Williams et al. (1999) where eprinomectin had consistently lower FEC than doramectin and ivermectin when different parasite control products, including eprinomectin, doramectin, ivermectin, and moxidectin, were compared to each other and/or the control group (Williams et al., 1999). When evaluating the FEC by month (Figure 3.1), there was a difference ( $P < 0.01$ ) at second month based on MW method. As shown in Figure 3.1, the FEC based on MM method in months 1, 2, and 3 were 67.3, 627.1, and 45.8 epg for heifers receiving DFT and 25.0, 247.7, and 13.0 epg for heifers treated with LGR, respectively. The FEC based on the MW method in months 1, 2, and 3 averaged 3.5, 72.3, and 10.5 epg for DFT heifers and 9.8, 20.7, and 9.1 epg for LGR heifers, respectively. Forbes et al. (2002) found lower concentrations of eggs

excreted in feces of treated calves (ranging from 0 to 250 epg with 73% of calves having less than 50 epg when compared to FEC of the untreated control group (ranging from 0 to 650 epg with only 58% of calves having less than 50 epg). Likewise, research from Hooke et al. (1997) reported similar results, where treating heifers with anthelmintics significantly lowered FEC. Besides controlling the gastrointestinal parasites in an animal species, using strategic deworming programs can also help reduce the larval loads of pastures (Stromberg and Auerbach, 1999). However, parasite loads of pasture were not assessed in this study.

The MM egg counting technique determines the burden of worms in an animal by counting the number of nematode eggs per gram of feces. Using this method requires special counting chambers; however, it is a quick method as the eggs are floated free of debris before counting (Whitlock, 1948). The MW method, on the other hand, has a higher sensitivity (Dryden et al., 2005). Negative results from this method indicates low levels or the absence of adult parasites. Low costs, ease to conduct, and the short period of time required for examination of the samples are some of the advantages to the MW method (Dryden et al., 2005). In this study, both methods were used to determine the egg counts in the feces. Young dairy heifers newly introduced to grazing showed lower FEC after the first month of grazing, regardless of which method was used. Using both methods, there was a marked increase in FEC after the second month of the study; however, FEC using the MW method, based on transformed data, were greater ( $P < 0.01$ ) for LGR than for DFT, though there was not a difference ( $P = 0.30$ ) when the feces were analyzed using the MM method at month 2. Both methods showed a decline in the FEC at month 3 and a difference was detected between the treatments while using MM method

( $P < 0.01$ ); however, MW method did not detect differences between the treatments in month 3 ( $P = 0.11$ ).

Several factors including season, worm type, and immune status of animals (Novartis, 2014) could be related to the variation in numbers of fecal eggs during month 1, 2, and 3 of this study. Most of the eggs that are deposited in April, May, and June develop slowly, and starting from the middle of July and onwards when the temperatures increase, the larvae reach the infective stage (L3) called “the mid-season rise” (Novartis, 2014). It is doubtful that the eggs deposited after September will develop to the infective stage of larvae (L3) because of the decrease in temperature as the season changes to autumn (Novartis, 2014). A similar pattern to this was observed in the current study. Temperature and precipitation data are provided in Figure 3.2 comparing year 2014 to previous 20 years. The first feces were collected on June 30, 2014, which showed lower egg counts, and followed the premise that the majority of eggs present in the pasture were not yet developed to L3 infective stage of larvae, so lower FEC were seen (Novartis, 2014). The second set of samples, which showed higher FEC were collected on July 28, 2014, which coincides to the time when the majority of eggs in the pasture will reach the L3 infective stage, resulting in high FEC. The third group of samples collected in this study was on August 25, 2014, which again showed lower FEC, likely as the season was getting closer to autumn and the number of eggs reaching the L3 infective stage was likely reduced, resulting in lower FEC in the heifers. Egg production based on the type of round worm varies from few hundred to several thousand per day (Novartis, 2014). Egg production capability is higher for *Haemonchus* than for *Trichostrongylus*, *Ostertagia*, and *Nematodirus* (Fox, 2014). Proportion of gastrointestinal parasite population was

determined in this study using coproculture. The average data is reported in Table 3.3 as the coprocultures were only done on composited samples. In this study, the numbers of *Heamonchus* were consistent throughout the months (Table 3.3), suggesting that high FEC in the second month were not caused by the increase of proportion of such high egg producing worms. Immunity status of the animals also plays a role in infection of gastrointestinal parasites (Novartis, 2014). Besides the contribution of injected anthelmintics towards lowering the density of gastrointestinal parasites in the gastrointestinal system of heifers, the immunity of animals might have played a role in lowering FEC over the course of this study.

Control of face flies (**FF**) and horn flies (**HF**) in the current study was evaluated. Results revealed that DFT tended ( $P = 0.08$ ) to reduce HF, and the average horn fly counts for DFT or LGR treatments were 9.7 and 17.2, respectively (Table 3.4). Average FF counts were 6.7 flies per heifer for DFT treatment and 9.2 flies per heifer for LGR treatment and were similar between treatments ( $P = 0.24$ ). Both FF and HF data based on the collection day from the start of the study is presented in Figure 3.3. Reduced fly counts due to the use of ear tags have been reported by several other studies (Kunz et al., 1984; Williams et al., 1980; Williams et al., 1981). Losses due to more than 50 species of ectoparasites have been reported to exceed \$2.26 billion in livestock each year (Byford et al., 1992). On an individual level, FF causes \$53.2 million and HF causes \$730.3 million losses annually (Byford et al., 1992). One potential way of controlling ectoparasites is through the use of ear tags impregnated with insecticide. Research by Ahrens (1977) used ear tags with 15% stirofos to control HF, which is historically considered the most important and economically damaging fly on cattle, and found that the tags efficiently

controlled flies for 12 to 14 wk due to slow release of the insecticide. A study by Boxall et al., (2007) looked the effect of parasite control products including the macrocyclic lactone doramectin, ivermectin pour-on, eprinomectin, and ivermectin injections and found that they effectively reduced the population of HF by 28, 6.8, 6.4, and 4.1%, respectively. An additional study by Floate et al. (2001) showed similar results when the investigators looked at the larvicidal activity of the fecal residues (of animals treated with anthelmintics) against HF, house flies, and stable flies. Anthelmintics were found to be effective in reducing fly counts, with the best control found when using doramectin, followed by ivermectin, eprinomectin (effective almost equal to ivermectin), and moxidectin (Floate et al., 2001).



### **3.6. Conclusions**

The ADG and skeletal growth of post-weaned grazing dairy heifers treated with either LGR or DFT were similar. The FEC was reduced at the end of summer for heifers treated with LGR. However, HF were reduced for heifers with fly tags when compared to heifers receiving only the LGR treatment. This study suggested that LGR was more efficient in controlling gastrointestinal parasites, as shown by reduced FEC, and fly tags provided better control for reducing HF in post-weaned grazing heifers during the summer months.

### **3.7. Acknowledgments**

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Table 3.1. Grain mix fed to dairy heifers at 1.7% of their starting body weight.

Item	DM%
Ground Corn	24.8
DDGS, Corn	6.4
Cottonseed hulls	24.0
Soybean Meal, 48%	12.8
Soyhulls	19.2
Corn Gluten feed	8.0
Yellow grease	3.2
Kent Active Heifer Mineral	1.6
<u>Nutrient Composition</u>	
DM, %	90.8
NEg, Mcal/kg	1.19
TDN, %	75.5
CP, %	15.3
NDF, %	41.2
ADF, %	27.6
Ca, %	1.0
P, %	0.8

Table 3.2. Initial and final growth data of heifers in DFT and LGR treatments.<sup>1</sup>

Item	DFT	LRG	SE	P-value
Initial body weight, kg	172.4	172.5	1.04	0.98
Final body weight, kg	249.4	250.1	1.04	0.70
Average daily gain, kg/d	0.92	0.92	0.02	0.79
Initial hip height, cm	113.1	113.1	0.29	0.96
Final hip height, cm	122.3	121.8	0.29	0.32
Change in hip height, cm	3.14	2.93	0.14	0.32
Initial wither height, cm	107.8	107.8	0.38	0.96
Final wither height, cm	116.6	116.8	0.39	0.80
Change in wither height, cm	2.97	3.02	0.18	0.86
Initial heart girth, cm	129.6	129.4	0.35	0.83
Final heart girth, cm	145.8	146.5	0.35	0.36
Change heart girth, cm	5.61	5.52	0.26	0.81
Initial hip width, cm	30.8	30.8	0.13	0.88
Final hip width, cm	36.5	36.6	0.13	0.61
Change in hip width, cm	1.89	1.97	0.09	0.55
Initial PUN, mg/dl	4.2	4.4	0.28	0.72
Final PUN, mg/dl	11.4	12.7	0.28	0.01
Initial BCS, 1 to 5 scale	2.78	2.78	0.02	0.88

Final BCS, 1 to 5 scale	2.96	2.97	0.02	0.84
Water intake, L/d per heifer	18.8	20.1	2.07	0.67

<sup>1</sup>DFT = Dectomax<sup>®</sup> (dormectin) and pyrethroid impregnated fly tags; LGR = 

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LongRange<sup>®</sup> (eprinomectin)

Table 3.3. The average number of L3<sup>a</sup> (infective larvae) based on Coproculture in DFT<sup>b</sup> and LGR<sup>c</sup> treatments

Larvae Type	DFT	LGR
Day 28		
Fecal egg count, eggs/g	39.5	13.0
<i>Heamonchus placei</i>	11.5	7.4
<i>Cooperia sp.</i>	0.0	2.4
<i>Nematodirus helvetianus</i>	0.0	0.0
<i>Oseophagostumum radiatum</i>	0.0	0.0
<i>Trichostrongylus</i>	0.0	0.0
<i>Coop. sp.</i>	6.2	0.4
<i>Ostertagia ostertagi</i>	0.0	0.0
<i>Coop. onc.</i>	16.6	2.8
Day 56		
Fecal egg count, eggs/g	105.5	37.0
<i>Heamonchus placei</i>	9.0	5.3
<i>Cooperia sp.</i>	0.0	29.8
<i>Nematodirus helvetianus</i>	0.0	0.0
<i>Oseophagostumum radiatum</i>	0.0	0.0
<i>Coop. sp.</i>	87.0	0.0
<i>Ostertagia ostertagi</i>	4.2	0.0
<i>Trichostrongylus</i>	0.0	0.0

<i>Coop. onc.</i>	15.8	1.9
Day 84		
Fecal egg count, eggs/g	105.0	23.0
<i>Heamonchus placei</i>	25.7	7.1
<i>Cooperia sp.</i>	0.0	6.8
<i>Nematodirus helvetianus</i>	0.0	0.5
<i>Oseophagostumum radiatum</i>	0.0	0.5
<i>Trichostrongylus</i>	0.0	0.5
<i>Coop. sp.</i>	48.3	6.3
<i>Ostertagia ostertagi</i>	2.1	0.5
<i>Coop. onc.</i>	28.9	0.0

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<sup>a</sup> Third stage of larvae (infective stage)

<sup>b</sup> Dectomax and fly tags, <sup>c</sup> LongRange

Table 3.4. Average face fly and horn fly counts over the study for heifers in DFT and LGR treatments.<sup>1</sup>

Item	DFT	LRG	SEM	P-value
Face fly counts, #/heifer	6.7	9.2	1.2	0.24
Horn fly counts #/heifer	9.7	17.2	2.6	0.08

<sup>1</sup>DFT = Dectomax<sup>®</sup> (dormectin) and pyrethroid impregnated fly tags; LGR =

LongRange<sup>®</sup> (eprinomectin)



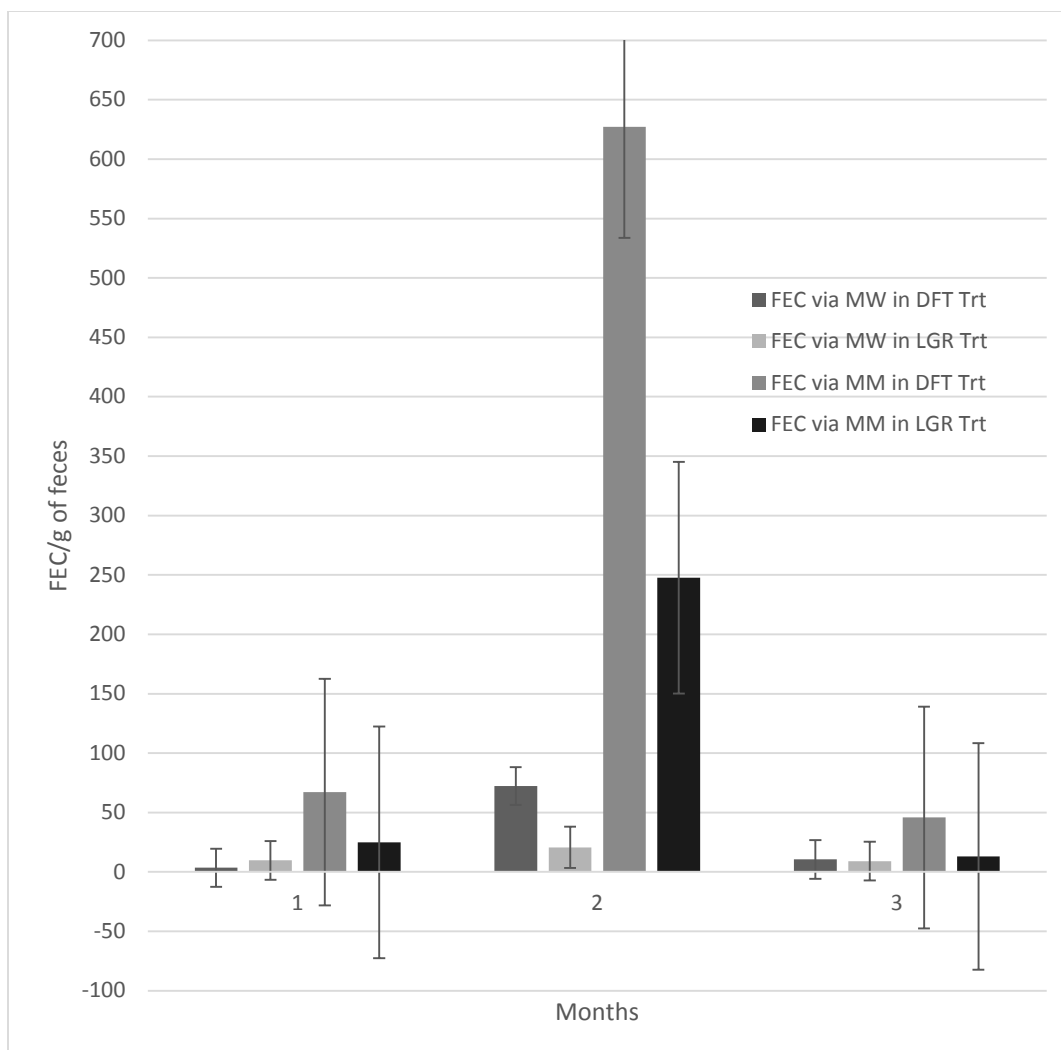


Figure 3.1. Fecal egg counts (FEC) for heifers treated with either Dectomax<sup>®</sup> (dormectin) and pyrethroid impregnated fly tags (DFT) or LongRange<sup>®</sup> (eprinomectin) (LGR) determined using either the Modified Wisconsin ( $P = 0.04$ ) or the McMaster method ( $P = 0.02$ ) for determination of FEC.

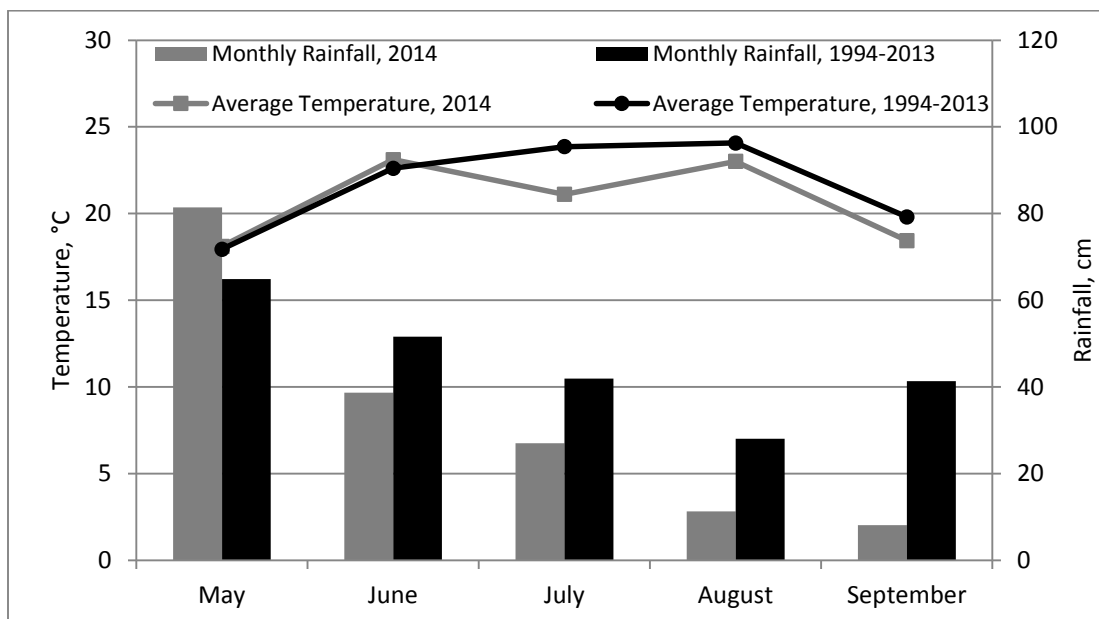


Figure 3.2. Average monthly temperature and precipitation for 2014 compared to averages from 1994 to 2013.

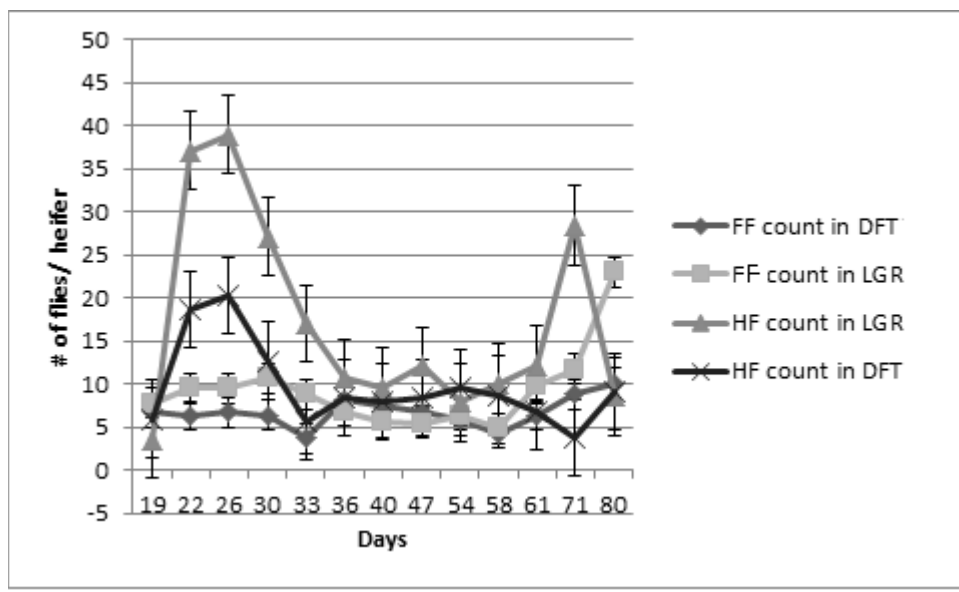


Figure 3.3. Face flies ( $P = 0.24$ ) and horn flies ( $P = 0.08$ ) in heifers treated with either Dectomax<sup>®</sup> (dormectin) and pyrethroid impregnated fly tags (DFT) or LongRange<sup>®</sup> (eprinomectin) (LGR).

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