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Master Thesis

Norwegian Red Heifers Grazing in Outfield Pastures of Southeastern Norway

A Case Study on Heifer Weight Gain and Body Condition

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Figure 1: Heifers at their perminant farm after the grazing season when after grazing body weights, body condition and fecal samples were taken (September 8, 2015): by author, 2015

Abstract

Livestock grazing on outfield pastures to utilize inexpensive forage and save infield pastures to harvest winter feed is an important focus topic in Norwegian agriculture. It is important for the health and biodiversity of native grassland communities to be maintained to prevent secondary succession. One method of grassland management is grazing cattle on outfield pastures. This develops a symbiotic relationship where native grassland is maintained while cattle are nourished without sacrificing their growth and development.

In Ringsaker and Vang almenning areas of Hedmark County, three dairy farms practice summer grazing on outfield pastures and allowed 41 of their Norwegian Red heifers to participate in this study. One farm allowed their heifers to forage freely (O-group) and the other farms had heifers in a restricted area (P-group). The aim of this study was to identify if an outfield grazing production system could support those heifers growth, body weight, and body condition as recommended by the Norwegian dairy coop Tine. Subsequently, I measured both live body weight and body condition of those 41 heifers.

The results indicated that the only heifers that gained body weight during the grazing season were those heifers that originated from the open grazing production system (O-group). The heifers in the O-group gained on average 17.4 kg while grazing on outfield pastures. Those heifers in the O-group were also the closest to the suggested weight recommended by Tine, with an average of 28.3 kg below the recommended weight for heifers’ respected ages. The heifers in the Pen grazing production system (P-group) lost an extensive amount of weight. Heifers in the P-group lost on average 60.9 kg, and were also 95 kg below their recommended Tine weight. In addition, this study also found a negative correlation between overweight heifers at the start of the grazing season and percentage body weight loss. Those heifers in our study that were the most overweight lost large percentage of their body weight over the grazing season.

In this study the results illustrate that grazing heifers on outfield pastures may be accomplished without sacrificing livestock production through the use of an open grazing management production system.

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1. Introduction

The world diet is changing, the number of people consuming animal products is increasing (Smith et al., 2007) and farms are being encouraged to gain efficiency in order to meet that growing demand (Gill, Smith, & Wilkinson, 2010; Godfray et al., 2010). Agriculture is expected to provide a society with high quality products, maintain cultural landscape (kulturlandskap), address consumers concerns, and minimize negative environmental impact while maintaining a reasonable price (Knutsen, 2006). Researchers and farmers understand that there is a need for continuous investment in research that creates sustainable agriculture practices that will meet the needs for future generations. Reksen, Tverdal, and Ropstad (1999) define sustainable agriculture as “agriculture that does not necessarily require subsidies of exogenous energy from finite resources, such as fossil fuels, or environmentally sensitive resources such as fertilizer and pesticides”. The sustainable agriculture movement has led to an increase in consumer’s awareness and preferences for pasture-based, less intensive cattle products (Farruggia et al., 2014).

Norwegian cattle production has a unique history. In Norway (excluding Svalbard) only about three percent (10,970 km^2) of the land is available for agriculture, due to its mountainous topography (Knutsen, 2006; Strand, 2013). Forest land makes up 37.3% (120,746 km^2) while heath and mountains makes up 45.4% (146,989 km^2) of land cover in Norway (Strand, 2013). During pre-industrial agriculture, a common practice was using livestock to graze forest and mountain pastures during the summer months (Myrdal, 1998). Grazing on outfield pastures became an essential tradition for increasing agriculture productivity. These mountain farms known as seters have three main functions “i) to provide summer pastures for animals in the outfields near the summer farm, ii) to be a production place for milk and milk products, and iii) to serve as a base for collection of additional winter fodder from an in-fenced area at the summer farm, as well as from a wide outfield area” (Bryn & Daugstad, 2001). The practice of grazing mountain and forest outfield pastures also made it possible to spare the productive infield pastures near the permanent farm for harvesting and then storing feed for use during the winter months (Austrheim, Solberg, Mysterud, Daverdin, & Andersen, 2008; Bryn & Daugstad, 2001; Potthoff, 2004). The number of seters peaked around the mid-19th century with around 50,000 seters across Norway (Bryn & Daugstad, 2001).

During the last decades, Norwegian agriculture has transformed from numerous farms with small herds, to fewer farms with larger herd sizes. The dairy cow population in Norway has fallen from 391,000 milking cows in 1980 to 233,200 milking cows in 2012. In 2012, 22% of all dairy farms had at least 30 milking cows when in 2002 only six percent of Norwegian dairy farms had herd sizes of at least 30 milking cows (Knutsen, 2006; Statistics Norway, 2012). After the agriculture intensification process, majority of those farms that survive the transformation abandoned the practice of summer grazing on outfield pastures (Knutsen, 2006; Sæther, Bøe, & Vangen, 2006a; Skarstad & Borgen, 2007).

1.1 Biodiversity Benefits of Outfield Grazing

The reduction of the outfield grazing practice has led to indirect land degradation of semi-natural habitat and the valuable ecological services native grasslands provide. Low grazing intensity has been proven to maintain grasslands, be beneficial to grassland plants and arthropod diversity, increase water infiltration, reduce ammonia emission and increase animal welfare (De Vires, 1995; Farruggia et al., 2014; Müller-Lindenlauf, Deittert, & Köpke, 2010; Wieren, 1995).

All across Europe, semi-natural grassland habitats are becoming fragmented and submitting to secondary succession forests (Bryn & Hemsing, 2012). It is estimated that between three and twelve percent of land changes in Norway has been forest re-growth (Bryn & Hemsing, 2012) and the largest cause of these land changes has been the termination of livestock grazing (Bryn & Hemsing, 2012; Hessle, Dahlström, Bele, Norderhaug, & Söderström, 2014; Hessle, Wissman, Bertilsson, & Burstedt, 2008). In Norway, about 30% of the Red List of Threatened Species (IUCN, 2015) is declining due to the reduction of semi-natural habitat (Duffey, 1974). In the United Kingdom semi-natural grasslands has declined by 90% since 1945 (Bullock et al., 2011b), and in Sweden there has also been a decrease of 90% leaving only about 200,000 hectares of semi-natural grassland (Hansson & Fogelfors, 2000; Lindborg & Eriksson, 2004).

Numerous plants that are used for agriculture cultivation e.g. perennial ryegrass (*Lolium perenne*) and white clover (*Trifolium repens*) derive from wild species of grasses found in outfield grasslands (Bullock et al., 2011a). The accelerated decline of semi-natural habitat poses a threat to agricultures grass genetic resources. With our current environmental state, it will be a benefit for plant breeders to have access to wild genetic resources to potentially integrate into domestic plant breeding. A project at Aberystwyth University in Wales is researching the genomics of non-agriculture grassland species that are adapted to environmental stressors such as drought or salinity; in addition, the project is exploring their prospective contribution for breeding with pasture plant to create varieties that are less sensitive to environmental stressors (John & Spangenberg, 2005). Thus it is critical to conserve and manage the current range of semi-natural grasslands in Norway to maintain grass genetic biodiversity of plants that are naturally resistant to environmental stressors. One method of managing semi-natural grassland is through the use of cattle grazing.

1.2 Norwegian Red

The dominating cattle breed in Norway is the Norwegian Red (Norsk Rødt fe, abbreviate NRF) (Global, s.a.; Skarstad & Borgen, 2007). Unlike other popular dairy cattle breeds e.g. Holstein, the NRF is a dual-purpose breed that is known for its milk production in addition to meat quality. During breed development the qualities that were important breeding criteria were high milk production, milk fat around four percent, fast growing animals, and good quality meat in addition to being good grazers. In the 1960s breeding weight was placed on milk production; however, today breeding weight has shifted to health and fertility with total merit index value placed on production index (28% TMI), udder health (18 % TMI), fertility (18% TMI), and udder conformation (18% TMI) (Global, s.a.). In 2009 the average NRF cow produced 7,057 kilograms of milk per year with a mean fat of 4.22% and protein of 3.37% (Nedrebø, 2010). Currently, average Norwegian dairy herds are at 4.2% for milk fat and 3.4% for protein of all lactations (Global, s.a.).

With livestock intensification the Norwegian Red breed has increased its productivity, and requires additional feed to reach its maximum production. Consequently, outlying pastures that once sustained milking cows in the past, may not meet the energy needs of a high producing, lactating Norwegian Red dairy cow. However, nutritional and caloric requirements of cattle vary depending on cattle's age, sex, breed, and lactation status. Young, non-lactating Norwegian Red heifers may be able to forage enough to meet their caloric requirements in addition, fit the ecological niche to maintain diversity of semi-natural grassland.

1.3 Heifer Bodyweight and Body Condition

In order to produce healthy and lasting dairy cows it is critical to manage replacement heifer's growth and development. During pre-pubertal phase (3-10 months of age) a heifer's growth consists of body weight, body size, and reproductive maturation (Ensminger, 1980). Studies have shown that the pre-pubertal phase is the most critical feeding phase and that milk yield is not affected by feeding level during pregnancy (Foldager & Sejrsen, 1991; Lacasse, Block, Guilbault, & Petitclerc, 1993). Required nutrients for heifers include energy, protein, minerals and vitamins; as the heifer grows the total nutrient intake (TDN), protein intake, and net energy requirements increase (Taylor, 1998). Well managed heifers can be bred starting at 13-15 months of age, and will calve around 22-24 months of age. Data shows that heifers calving at 22-24 months of age are the most productive and return more income then heifers that calve later in their life (Ensminger, 1980).

John Hammond (1962) termed the development of animals as a series of 'growth waves'. The first wave of growth is when nerve and bone tissues are given priority for nutrients and grow rapidly; next is muscle tissues, and finally adipose tissues are given priority. When animals grow too fast, these waves of growth can overlap with each other. Rapid growth can cause extensive amounts of fat to be deposited (McDonald et al., 2011). Heifers that are fed a high energy diet during the pre-pubertal phase will most likely undergo rapid gain in body weight. Rapid gain in body weight has been linked to abnormal fat deposits, which damages mammary development through the displacement of lipids and secretory cells which consequently impairs milk production (Mäntysaari, Ingvartsen, Toivonen, & Sejrsen, 1995; Owens, Dubeski, & Hanson, 1993; Sejrsen, Huber, Tucker, & Akers, 1982; Sejrsen & Purup, 1997; Sejrsen, Purup, Martinussen, & Vestergaard, 1998; Sejrsen, Purup, Vestergaard, & Foldager, 2000). According to Silva, VandeHaar, Whitlock, Radcliff, and Tucker (2002), heifers that were fatter tended to have compromised mammary development than thinner heifers. A Danish experiment by Hohenboken, Foldager, Jensen, Madsen, and Andersen (1995) using Danish Friesians, Danish Reds, and Danish Jerseys concluded that in each breed, the group of heifers that was fed the highest feeding level during pre-pubertal age had the lowest milk yield during their lactation. Growth wave pattern is similar in all breeds of cattle; however, the feeding level triggering the decrease in milk yield differs between breeds (Hohenboken et al., 1995).

It is not necessarily rapid body weight gain but rather a high gain in body fat that is the factor in deciding a heifers mammary development (Silva et al., 2002). Therefore, it is critical that in addition to manage heifers' body weight, one should also manage their body condition. Body condition scoring is a method of management that is the assessments of the amount of fat an animal has. Body fat reserves play an important role in early lactation, by shielding the cow against feed shortages while she uses the energy from her feed mainly towards milk production (Garnsworthy, 2007). A heifer at the correct body condition will need less calving assistance and produce more milk during her first lactation (Dairy Austraila, 2011; Ensminger, 1980; Silva et al., 2002). Evidence shows that extremes at both ends of the body condition spectrum at calving is associated with poor cow health such as dystocia, retained placenta, metritis, milk fever, mastitis, lameness, fatty liver and ketosis (Berry et al., 2007; Garnsworthy, 2007; Gearhart et al., 1990; Markusfeld, Galon, & Ezra, 1997; Roche & Berry, 2006; Roche et al., 2009; Swanson, 1967; Treacher, Reid, & Roberts, 1986). Both cows and heifers that are unreasonably fat at calving are more likely to develop fatty liver and ketosis because, a high body condition depresses appetite and the body fat is mobilized too rapidly (Reid, Roberts, Treacher, & Williams, 1986). Fatty liver is defined at >20% fat in liver cells or >50g/kg of triglycerides liver tissues (Newbold, Garnsworthy, & Wiseman, 2006). Cattle that suffer from fatty liver have severe negative energy balance, poor reproductive performance, and increased incidence of diseases (Treacher et al., 1986). The study done by Gillund, Reksen, Gröhn, and Karlberg (2001) included 732 moderate-yielding Norwegian Red cows, and showed that cows with a body condition score of 3.5 or greater were 2.3-2.8 times more likely to experience ketosis compared to cows with a body condition of 3.25 or lower.

Many farmers strive for a management plan that will allow heifers to grow to their full lactation potential at a desired age and at the minimum expense. The Norwegian company Tine, which is the largest Norwegian dairy cooperative, consults Norwegian dairy farmers to help make their farms profitable and sustainable. Tine has estimated that the cost of raising replacement heifers can be as much as 25-30% of a Norwegian dairy farms total expense. Tine has distributed body size recommendations and ideal live weight gain for NRF heifers from three months of age to calving **(Table 1)** for farmers to manage heifers to become robust, healthy and economically efficient milking cows (Tine, 2014).

Scales are the most accurate way of calculating an animal's body weight; on the other hand, measuring the diameter of the animals heart girth is also an accurate measurement because hearth girth demonstrates the highest correlation to body weight (Ensminger, 1980; Heinrichs, Rogers, & Cooper, 1992).

Table 1: Recommended bust, weight, weight gain and concentrate consumed for corresponding age of NRF heifers by Tine, Norway's largest dairy cooperative

Age	Bust	Weight	Weight Gain	Concentrate
3 months	102 cm	106 kg	784 g	2 kg
5 months	117cm	155 kg	816 g	2 kg
7 months	130 cm	205 kg	831 g	1.7 kg
9 months	142 cm	256 kg	829 g	1.3 kg
11 months	152 cm	306 kg	808 g	0.9 kg
13 months	160 cm	354 kg	776 g	0.3 kg
15 months	168 cm	400 kg	726 g	0.3 kg
17 months	174 cm	441 kg	666 g	
19 months	179 cm	480 kg	608 g	
21 months	184 cm	515 kg	540 g	
23 months	188 cm	546 kg	472 g	
24 months	193 cm	560 kg	443 g	Calving

1.4 Justification of Study

According to Farruggia et al. (2014), continuous grazing cattle production maintains high biodiversity levels of outlying lands, and uses less synthetic inputs in management when compared to conventional cattle farming. In addition, grazing cattle takes advantage of the ruminant's ability to turn human-inedible plants into human-edible products. The common practice in Norway is to have cattle graze either on infield pastures or outlying pastures during the summer months. This is partly due to Norwegian regulations of a minimum of eight weeks of outdoor exercise (Skarstad & Borgen, 2007) and partly because of pasture subsidies to “increase the number of grazing livestock on both cultivated pastures and on rough grazing land, mountain pastures, etc” (Knutsen, 2006). There is a high energy demand of cultivated infield pastures for grazing due to fertilizer used to maintain fertile, lush pastures (Müller-Lindenlauf et al., 2010). The ministry of agriculture reported "importance should be given to knowledge-based utilization of resources in outlying lands by mapping grazing resources and pasture quality, encouraging efficient land use, focusing on quality production and profitability to a greater extent, and increasing emphasis on the synergy between grazing and other social considerations” (Landbruks-og matedepartementet, 2011). The report has sparked an interest in exploring less intensive grazing practices by utilizing outlying pastures as a possible management option for raising heifers; saving fertile inland pastures for harvesting of winter feed, grazing high production cows, or growing human edible food. Cattle grazing on outlying pastures often cover long-distances in search for food and water that can cause a negative energy balance, affecting the animal's body productivity (Henning, 1987; Lawrence & Stibbards, 1990; Maurya, Sejian, Kumar, & Naqvi, 2010). However, species rich semi-natural grassland could provide the opportunity for heifers to forage and graze specific plants and vegetation with diverse nutrient qualities to meet their energy demands (Sæther et al., 2006a; Sæther, Sickel, Norderhaug, Sickel, & Vangen, 2006b).

The objective on this study is to explore how NRF heifers weight gain and body condition are affected by grazing on outlying pastures throughout the grazing season. I measured both body condition and body weight to discover if heifers grazing either in-fenced mountain farm pastures or free range grazing on outlying pastures have the opportunity to forage enough to meet their nutritional requirements. This study defined meeting nutritional requirement as heifers that weight close to the Tine (2014) recommendations for NRF heifers **Table 1**. My hypothesis for this study is that, because of high diversity of plants available, NRF heifers will be able to forage enough vegetation to meet their nutritional requirements and maintain appropriate body condition as they continue to grow during the summer grazing season.

2. Materials and Methods

2.1 Animals and Heifer Field-Work

In the summer of 2015 NRF (*Norsk rødt fe*) heifers (n=41) from three different farms with two different grazing management production systems were weighed and body condition scores were recorded before and after the grazing season. Farm A heifers had an open grazing management production system (O-group) which is defined in this study as heifers having no restrictions on where they can forage. Farm B and Farm C had a Pen grazing management production system (P-group) which is defined in the study as heifers foraging on outfield pastures but being restricted due to a fenced area **(Figure 2 and Figure 3)**. All the grazing locations were located in Hedmark County in Southern Norway. The mean age of heifers in this study was 88.80 weeks (Farm A 101.37 weeks, Farm B 89.03 weeks, Farm C 79.27 weeks) with a range of 42.86 weeks of age to 138.43 weeks of age. Before the study, heifers on all the farms were fed a diet of good-quality grass silage.

On Farm A, 12 heifers were initially part of the study and of those 12 heifers, six were confirmed pregnant. However, during the study, three heifers were removed due to management decisions. One pregnant, one open (not pregnant) and one old heifer was remove from the study. Farm A heifers first spent 40 days (May 22, 2015- July 1, 2015) grazing on infield pastures near their permanent farm before being released on outfield pastures and spent a total of 73 days grazing (July 1, 2015- September 12, 2015). Farm B originally had 21 heifers, 11 pregnant and 10 open, reserved for this study. During the preparation for the summer grazing there were management decisions that removed five of the original heifers and added three new heifers. Due to the management decisions shortly before grazing season begun, body condition score was not conducted on the three new heifers before they started grazing. Farm B heifers spent a total of 83 days on pasture (June 23, 2015- September 15, 2015). Farm C had 16 heifers, eight of those heifers being confirmed pregnant. All 16 heifers had both body condition and body weights measurements taken both before and after the summer grazing season; however, three heifers were removed from the study due to their age. Farm C heifers spent a total of 69 days out on pasture (June 25, 2015- September 2, 2015). According to Potthoff (2004) the average fluctuation for animals on mountain farms was between 58 and 76 days and the herd average being 20-35 cows (Valvik, 1998).

2.1.1 Heifer Field-Work

Live body weights of the heifers were conducted using a standard scale measured in kilograms. Body condition scores was measured using a five-point scale (.25 increments) where a score of one represents an emaciated animal and a score of five represents an very overweight animal (Ferguson, Galligan, & Thomsen, 1994). Heifers were scored on appearance and palpation of back and posterior area. Heifers were evaluated on the condition of their vertebral column (loin and rump), tailhead, hook bones, sacral ligament, pin bones and tailhead ligament. Suggested by Wildman et al. (1982), we looked at all the factors to provide an accurate score. According to a study by Ferguson (1996) four observers took body condition scores of 57 cows ranging in body condition. There were significant, but small differences between the observers. Due to this observation, only one person conducted all of the body condition scores to avoid judgement errors and provide an accurate score. See **Appendix I: Body Condition Score** for pictures and in depth description of each score of body condition.

Farm A body condition scores were conducted on May 11, 2015 and body weights were measured on May 22, 2015, the same day Farm A heifers were released onto infield pastures. Body weights were also measured on July 1, 2015 when Farm A heifers were released onto mountain pastures. Farm B body condition scores were conducted on May 5, 2015 and body weights were measured on June 23, 2015 the same day they were released onto outfield pastures. Farm C body condition scores and body weights were collected the same day on June 8, 2015, and Farm C heifers were released onto outfield pastures on June 25, 2015.

2.2 Study Location

Study locations included Ringsaker almenning where Farm A and Farm B heifers spent the grazing season and in the Vang almenning where Farm C heifers spent the grazing season. Both almenning areas are in Hedmark County, in the south-eastern part of Norway.

Farm A heifers after grazing on infield pastures (May 22, 2015- July 1, 2015) were released onto Kvarstad Setra at 61° 10’ 94” N, 10° 52’ 66” E, 690 meters above sea level, for 73 days and were able to freely roam on the pasture area and forage varying species of plants found in North Boreal Zones. Farm B heifers were released onto Farm B pasture at 61° 13' 59.99" N, 10° 49' 0.01" E, (**Figure 2**), a fenced area of 6.77 hectares and 740 meters above sea level in the North Boreal Zone. Farm C heifers were released onto Farm C pasture at 60° 54' 00" N, 11° 11' 00" E (**Figure 3**), also a fenced area of 5.67 hectares and 590 meters above sea level in the Middle Boreal Zones (closed forest). **Table 2** defines the summer of 2015 average temperature, precipitation, and wind speed for both Farm B pasture and Farm C pasture (YR, s.a.).

Figure 2: Area photo of the grazing area for Farm B: photo from Norsk institutt for skog og landskap

Figure 3: Area photo of the grazing area for Farm C heifers: photo from Norsk institutt for skog og landskap

Table 2: Average temperature, precipitation, and wind speed for Pasture B and Pasture C grazing sites during the grazing season

Month	Temperature Average (Warmest, Coldest) Farm B Pasture	Temperature Average (Warmest, Coldest) Farm C Pasture	Precipitation Farm B Pasture (Highest daily value)	Precipitation Farm C Pasture (Highest daily value)	Wind Speed Farm B Pasture (Strongest -t wind)	Wind Speed Farm C Pasture (Strongest -t wind)
June 2015	12.4ºC (22.9 ºC, 2.4 ºC)	12.7ºC (22.8ºC, 2.1ºC)	53.5mm (16.mm)	54.7mm (19.9mm)	2.1m/s (8.3m/s)	2.5m/s (9.2 m/s)
July 2015	14.8ºC (28.4ºC, 5.5ºC)	15.0ºC (28ºC, 6.2ºC)	103.5mm (25.8mm)	103.0mm (14.2mm)	1.9m/s (8.9m/s)	2.3m/s (10.7 m/s)
August 2015	14.3ºC (23.6ºC, 4.9ºC)	15.3ºC (24.8ºC, 6.6ºC)	100.3mm (25.2mm)	81.9mm (20.6mm)	1.5m/s (6.7m/s)	1.8m/s (8.2 m/s)

2.3 Vegetation Analysis

Before the heifers were released to graze on outfield pastures, a vegetation analysis was conducted on both Farm B pasture and Farm C pasture. The analysis was conducted using the dry weight rank method (Coulloudon, 1999) and only genus composition was identified. A total of 40 samples from each pasture were randomly selected throughout the field using a 40cm by 40cm metal frame (**Figure 4).** Starting at the entrance to the pasture the observer tossed the quadrat square in a random direction. In each quadrat, the genera of the plants were observed and the most abundant genera were ranked according to greatest dry mass weight. The plant variety that had the greatest weight was given a score of 1, with the next greatest weight given a score of 2 and the third highest weight a score of 3. All other varieties were ignored. Dry weight rank method infers that a rank of 1 represents that the plant variety makes up about 70% of the total dry weight, a rank of 2 equals that plant variety is about 20% of the total dry weight, and rank of 3 about 10% of the total dry weight. There were quadrats where three genus varieties were not present. If only one genus variety was found then it was ranked 1, 2, 3 (100%). If two genus varieties were found the most frequent was given a score of 1, 2 (90%), 1, 3 (80%) or rank 2, 3 (30%) depending on the relative weight. Once that data was collected, the observer then walked 10 paces diagonally across the field and again threw the square in a random direction and repeated the process until 40 random squares from around the pasture were observed.

Figure 4: The 40cm by 40cm metal frame that was used to collect vegetation samples. Photo is from Pasture B taken on June 23, 2015: by author, 2016

For each quadrant, the 1, 2, or 3 scores of the top 3 ranked genera were multiplied by 7, 2 and 1, respectively to represent approximated 70%, 20%, and 10% of the dry matter in that quadrant. Those numbers were recorded in the weight column. That number in the weight column was added together for each genus number throughout the entire field giving a total field weight. Each species weight was then divided by that total field weight giving a percentage of each plant variety present in the field. **Appendix IV: Dry Weight Rank.**

In both Farm B pasture and Farm C pasture there were some similar genera of plants found, including *Deschampsia, Ranunculs, Poa, Rumex,* and *Juncaceae.* Farm B pasture was the most diverse with a total of 14 different genera of plants that made one of the top three highest percentages in the field. In Farm C pasture only eight different genera of plants were found that made the top three highest percentages in the field.

In Farm B pasture, there were similar genera found but different composition of those genus varieties. *Carex* was the most dominant genus which established 38% of the field and *Deschampsia* at 29%. Minor dominant species included *Juncaceae* (10%), *Rumex* (4%), *Rannculs* (3%), *Poa, Cardamine, Vaccinium, Trifolium* (2%) and the genus *Phleum*, *Equisetacae, Viola, Caltha, and Stellarie Media* covered <1% of the field. In Farm C pasture, the dominating genus was *Cyperaceae* which was found to cover 64% of the field. Followed by *Deschampsia* (18%), *Poa* (5%), *Juncaceae* (5%), *Violaceae* (3%), *Ranunculus* (2%), *Luzula*, and *Rumex* (<1%) of the genus composition. Other plant varieties that were present in the field included *Taraxacum officinale* (common Dandelion), *Trifolium repens* (White Clover), *Cerastium*, and *Phleum pretense (*Timothy-Grass); however, their presence did not make the top ranking.

2.4 After Grazing Season

Farm A heifers' after grazing weights were conducted on September 12, 2015 the same day they were taken back to the permanent farm. Body condition and fecal samples were collected later that month on September 21, 2015. Farm B heifers' after grazing weights were conducted on September 5, 2015 the same day they were taken from Pasture B to the permanent farm. Body condition scores and fecal samples were collected on September 9, 2015. Farm C heifers were returned to the farm on September 2, 2015 and after grazing body weight, fecal samples, and body condition scores were conducted on September 8th 2015.

2.4.1 Fecal Sampling

Fecal samples were taken and then analyzed by the Veterinærinstituttet (Norwegian Veterinary Institute) to test the presence of parasites. 10 grams of fresh fecal samples were collected from five heifers from Farm B and five heifers from Farm C. We deposited those fresh fecal samples into plastic baggies and the same day placed in the post to Veterinærinstituttet to test for the presence of Eimeria (coccidia) and Strongyle-type (eggs laid by nematodes) microorganisms. Eight heifers (four heifers from Farm B and four heifers from Farm C) tested positive for one of the parasites present, and only two heifers both originating from Farm B tested positive for both parasites. All assessments concluded if there were parasites present they were at sparse levels. **Table 6** in **Appendix III: Results Parasite Testing.**

2.4.2 Pasture Condition Scores

After the grazing season, a pasture condition score (PCS) was conducted on Farm B pasture and Farm C pasture. Because of the diverse variables of the pastures, forage qualities were analyzed only by descriptive means. The PCS is a monitoring and assessment tool used to stress individual characteristics of pastureland (Sanderson, 2014). There are a total of 10 categories that make up the PCS and depending on the quality of each category the pasture is given a score of very poor, poor, good, or very good. The categories are plant desirability, plant diversity, plant density, plant vigor, percent legume, severity of use, uniformity of use, soil erosion, woody canopy, and plant residue. Each category is given a score between 0-4 with 0 being undesirable and 4 being desirable. Once a score is given to each category all the scores are added up. If a pasture scores 1-10 then it is very poor, 11-20 it is poor, 21-30 it is good, and a score of 31-40 it is very good (Cosgrove, Undersander, & Davis, 1996).

Pasture B and Pasture C have been grazed by cattle for many years. The overuse of grazing can considerably affect the plant community structure (Kauffman & Krueger, 1984) which can then affect the value of the pasture. The pasture condition of Pasture C was ranked very poor, with a score of 4 out of a possible score of 40. The pasture was observed as a marshy wetland and in Pasture C there was some tree cover and a barn; however, overall there was little cover for the animals to get out of the weather extremes e.g. rain. Farm C pasture scored a 0 on all the categories except for Plant Diversity, Plant Desirability, and Uniformity of Use **(Table 5 Appendix II: Pasture Condition Scoresheet).** Farm B pasture was ranked poor, with a score of 19 out of the possible score of 40. In Farm B pasture the only categories where it scored a 0 was in Soil Erosion, and Woody Canopy. Farm B pasture had characteristics of a typical marshland including a swampy area with many tufts of *Deschampsia* that had the appearance of having not been grazed. About five percent of the area in Pasture B was made up of woodland type species of shrubs and tree cover, there was no evidence that the heifers grazed in that area. In Farm B pasture there was a clear area and there was evidence that the heifer spent their time grazing in that area e.g. well grazed grass, many piles of bovine excrement, and green grass was starting to regrow.

2.5 Calculations

The weight change was calculated by subtracting the heifers end weight taken in autumn from the heifers starting weight taken in the early summer. Weight difference from Tine recommendations was calculated by subtracting the heifer's weight from the corresponding Tine recommended weight in accordance to heifer's age. The impact of different variables on heifer bodyweight change was tested by ANOVA and backwards selection in R statistical package The R Foundation for Statistical Computing (2014) using lm function.

3. Results

3.1 Body Condition

The body condition scores remained relatively steady. There was a small decrease of .15 points in body condition from the entire population (n=38) and very minor changes of body condition from the different grazing management production systems. Detailed information on the specific body conditions is given in **Table 3**.

Table 3: Body condition scores of all animals grouped by total herd population, O-group and P-group with the average body condition, minimum body condition, maximum body condition observed and average change of body condition during the grazing season

	Average (min, max) Before	Average (min, max) After	Average Change in BCS
Total Average (n=42)	3.52 points (3.00 points, 3.75 points)	3.37 points (2.75 points, 3.75 points)	-0.15 points
O-Group (n=9)	3.53 points (3.50 points, 3.75 points)	3.56 points (3.50 points, 3.75 points)	0.03 points
P-Group (n=29)	3.52 points (3.00 points, 3.75 points)	3.31 points (2.75 points, 3.75 points)	-0.21 points

3.2 Weight Development

The total (n=41) weights of heifers decreased considerably (mean weight change -43.2 kg) during the grazing season. 85% of the total heifer population lost weight and only 15% gained weight, all of which originated from the O-group. Heifers from the O-group (n=9) on average lost 5.2 kg (SD± 12.56) during their time grazing on infield pastures. When they were on outfield pastures there was an average gain of 17.4 kg (SD ±1) in live body weight. O-group heifers also had a weight gain of 12.2 kg (SD ± 13.3) over the entire summer grazing season. The heifers in the P-group (n=32) on average lost 60.9 kg (SD ± 46.0). Farm B heifers (n=19) had an average weight loss of 56.7 kg (SD ±41.7) and Farm C heifers (n=13) had an average weight loss of 67.0 kg (SD ± 35.9). When the total population of heifers (n=41) was considered, 76% of the heifers lost 20 kg or greater and with the greatest weight loss being 173 kg. The weight change over the grazing season by farm is shown in **figure 5.**

Grazing management was significant in the heifers weight change over the grazing season ($p<.001$, $F=48.11$). Those heifers that had similar grazing management e.g. heifers from Farm B vs Farm C, were not significantly different. In addition the O-group heifers grazing on infield pasture vs outfield pasture was not significantly different. The other combinations of heifer weight change averages however were significantly different **Table 4**.

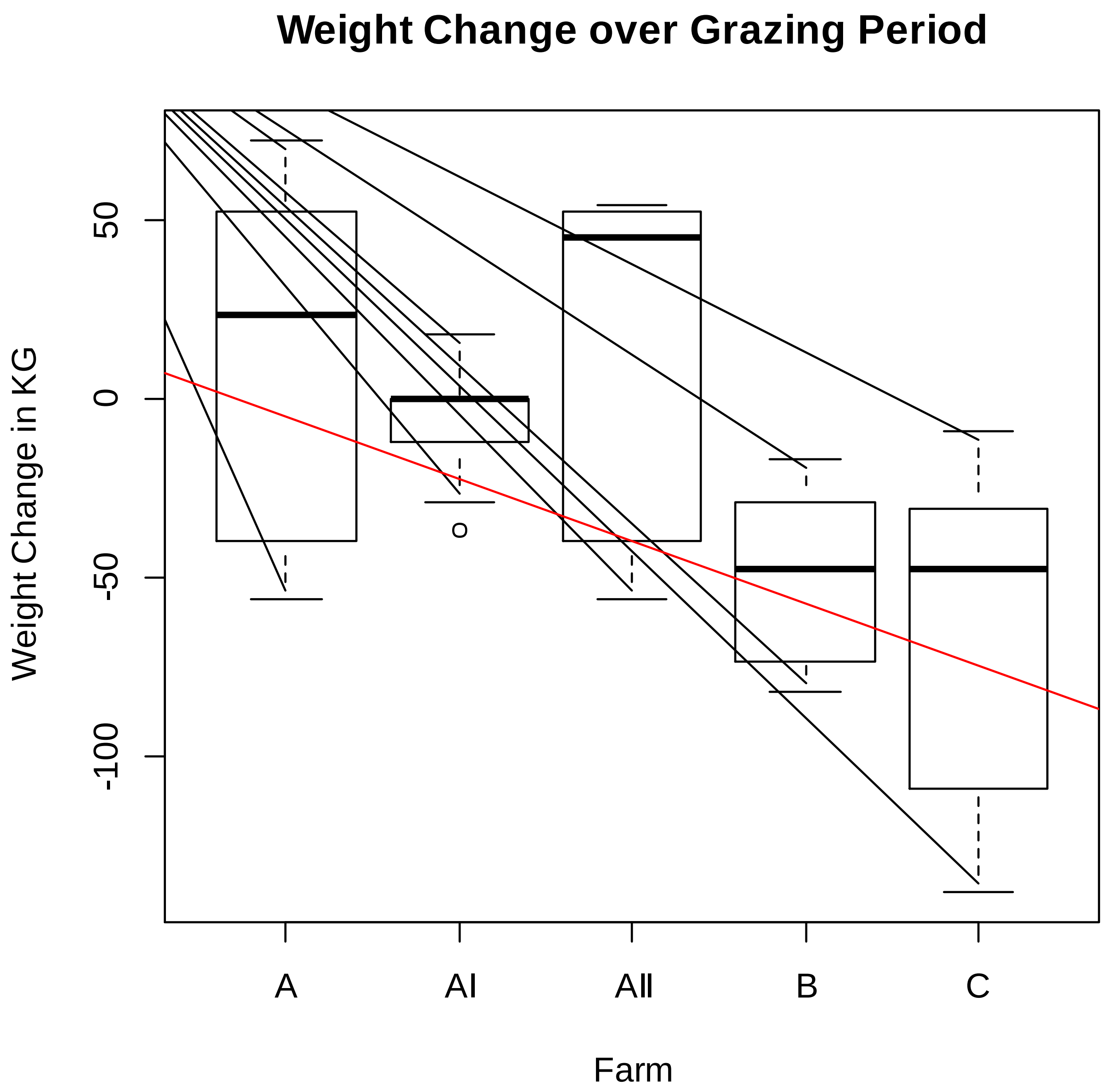

Figure 5: Weight Change in KG (Y-axis) of 3 farms (A,AI,AII,B,C) in Hedmark County (X-axis). Farm A is divided into 3 bars (A, AI, AII) (A) represents the heifers weight change over the entire grazing season (May 22, 2015- September 12, 2015). AI represents the first period on infield pastures (May 22, 2015- July 1, 20015) at the farm and (AII) represents the period when the heifers grazed on mountain pastures (July 1, 2015- September 12, 2015). All weight change was calculated by subtracting weight at the end of the time period from the heifers starting weight. The box represents 50% of the middle data (values ranked lowest to highest), with the dark solid line representing the mean weight change. The lines represent the range of data the lowest 25% of the values and upper 25% of the values

Table 4: Results from tukey test in mean weight change between combinations of heifer groups. The first 2 columns (Group 1 Heifers and Group 2 Heifers) in the table are the groups of heifers that were tested against each other. The third column is the p-value of that test; and the last column is the conclusion of that test.

Group 1 Heifers	**Group 2 Heifers**	**P-value**	**Significance**
Farm A Infield Grazing: O-group	Farm A Entire Grazing Season: O-group	1.000	Not significantly different
Farm A Outfield Grazing: O-group	Farm A Entire Grazing Season: O-group	0.999	Not significantly different
Farm B Heifers: P-group	Farm A Entire Grazing Season: O-group	0.002	Significantly different
Farm C Heifers: P-group	Farm A Entire Grazing Season: O-group	0.001	Significantly different
Farm B Heifers: P-group	Farm A infield grazing: O-group	0.002	Significantly different
Farm C Heifers: P-group	Farm A infield grazing: O-group	0.001	Significantly different
Farm B Heifers: P-group	Farm A Outfield grazing: O-group	0.001	Significantly different
Farm C Heifers: P-group	Farm A Outfield grazing: O-group	0.0005	Significantly different
Farm C Heifers: P-group	Farm B Heifers: P-group	0.967	Not significantly different

3.3 Weight in Accordance with Tine Recommendations

After the grazing season, 89% of the heifers (n=38) were under the recommended weight suggested by Tine (2014) (minimum 152 kg below Tine recommendations, maximum 34 kg above Tine recommendations). The heifers (n=38) on average were 79 kg (SD ±5.0) below their suggested weight for their age. 11% of the heifers' weights were above the Tine recommendations and all those heifers originated from the O-group. O-group heifers (n=9) were the closest to the suggested weight with an average 28.3 kg (SD± 6.8) below the Tine recommendations. Heifers in the P-group (n=29) were on average 95 kg (SD ±5.0) below the recommended weight. In the P-group, Farm B heifers (n=16) on average were 99 kg (SD± 8.5) and Farm C heifers (n=13) on average were 90 kg (SD ±5.0) below the recommended Tine weight for their respective ages.

Individual heifers can vary 20% from the breed average (Swanson, 1967), and 58% of the heifers from this study fell within the recommended ± 20% of their recommended weight. None of the heifers were above the recommended range of ± 20% and 42% of the heifers were below the recommended weight range of ± 20%. Each heifer grouped by age and how their individual weight fell within the Tine recommendation of ± 20% is illustrated by **figure 6**.

Heifers from farms that had similar grazing management production systems were not significantly different in their variance from the Tine recommendations e.g. Farm C heifers to Farm B heifers ($p>0.05$). However, heifers from farms with different grazing management systems were significantly different, e.g. Farm B heifers to Farm A heifers ($p<.0001$), and Farm C heifers to Farm A heifers ($p<0.001$).

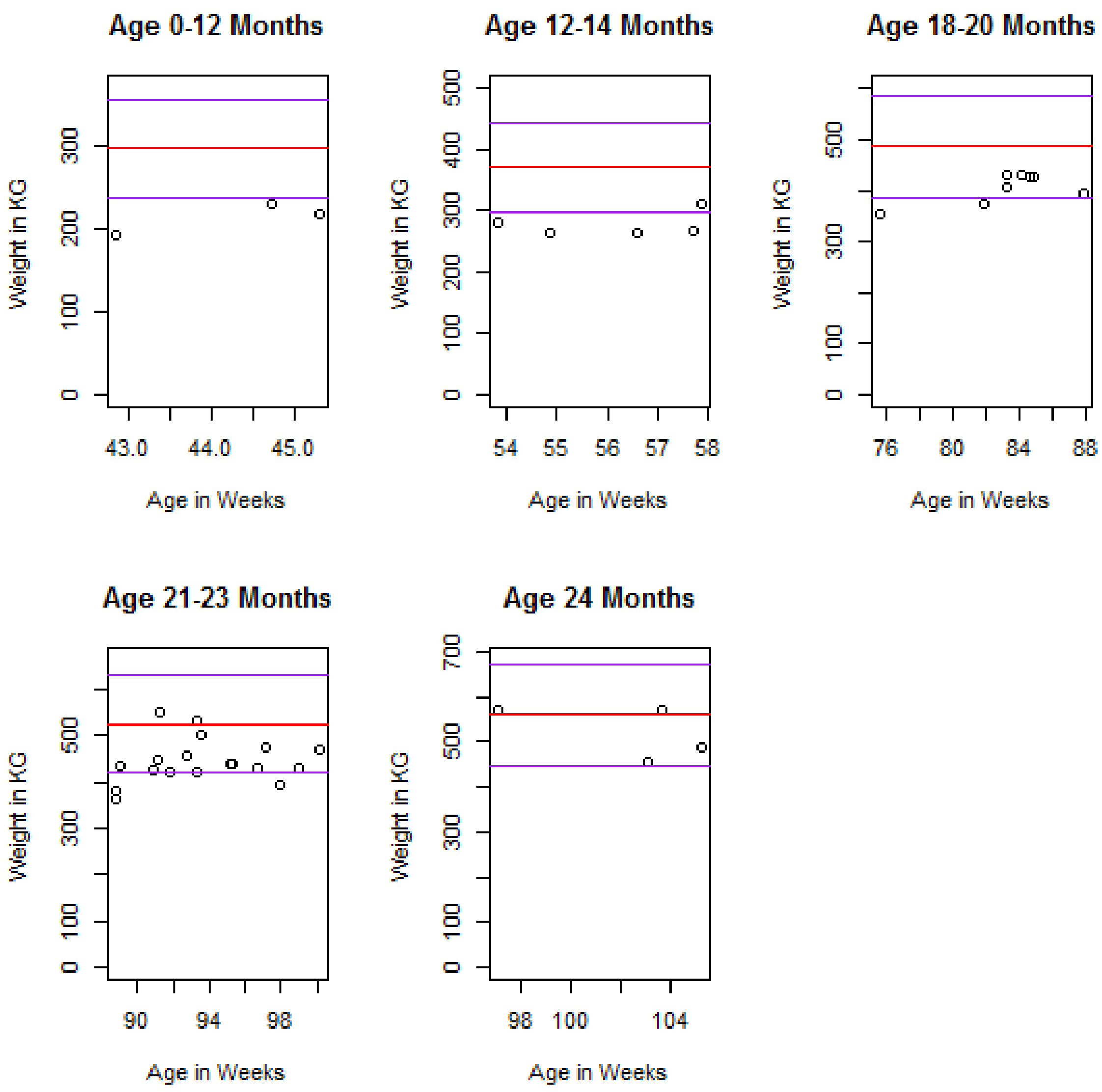

Figure 6: Weight of heifers (Y-axis) separated by different age groups in weeks (X-axis). Each heifer is represented by a dot. The red line represents the Tine recommended weight for each age group. The lower purple line represents the lower 20% and upper purple line represents the upper 20% of the Tine Recommendations.

The gap between the heifers’ after body weight and their Tine recommended weight was noticeably different then the difference in the heifers’ before body weight and their Tine recommended weight. Before the study, heifers were on average 35.6 kg above their recommended weight (minimum -61 kg, maximum 129 kg, and SD ± 31.6). The O-group heifers (n=9) were 29.5 kg above their recommended weight (minimum -18 kg, maximum 113 kg, SD± 22.6). The P-group heifers (n=29) were 37.5 kg above the Tine recommended weight (minimum -61 kg, maximum 129 kg SD± 31.6). From the P-group, Farm B heifers (n=16) were on average 25.5 kg (SD ±16.6) above the suggested weight and Farm C heifers (n=13) were 52.3 kg (SD ± 31.1) above the recommended weight. Over the grazing season, 71% of the total heifers (n=38) went from being above their Tine recommended weight to below their Tine recommended weight. Over the grazing season 18% of the heifers had weights that stayed below the Tine recommended weights and 11% of the heifers’ had weights that stayed above the Tine recommended weights **Figure 7.**

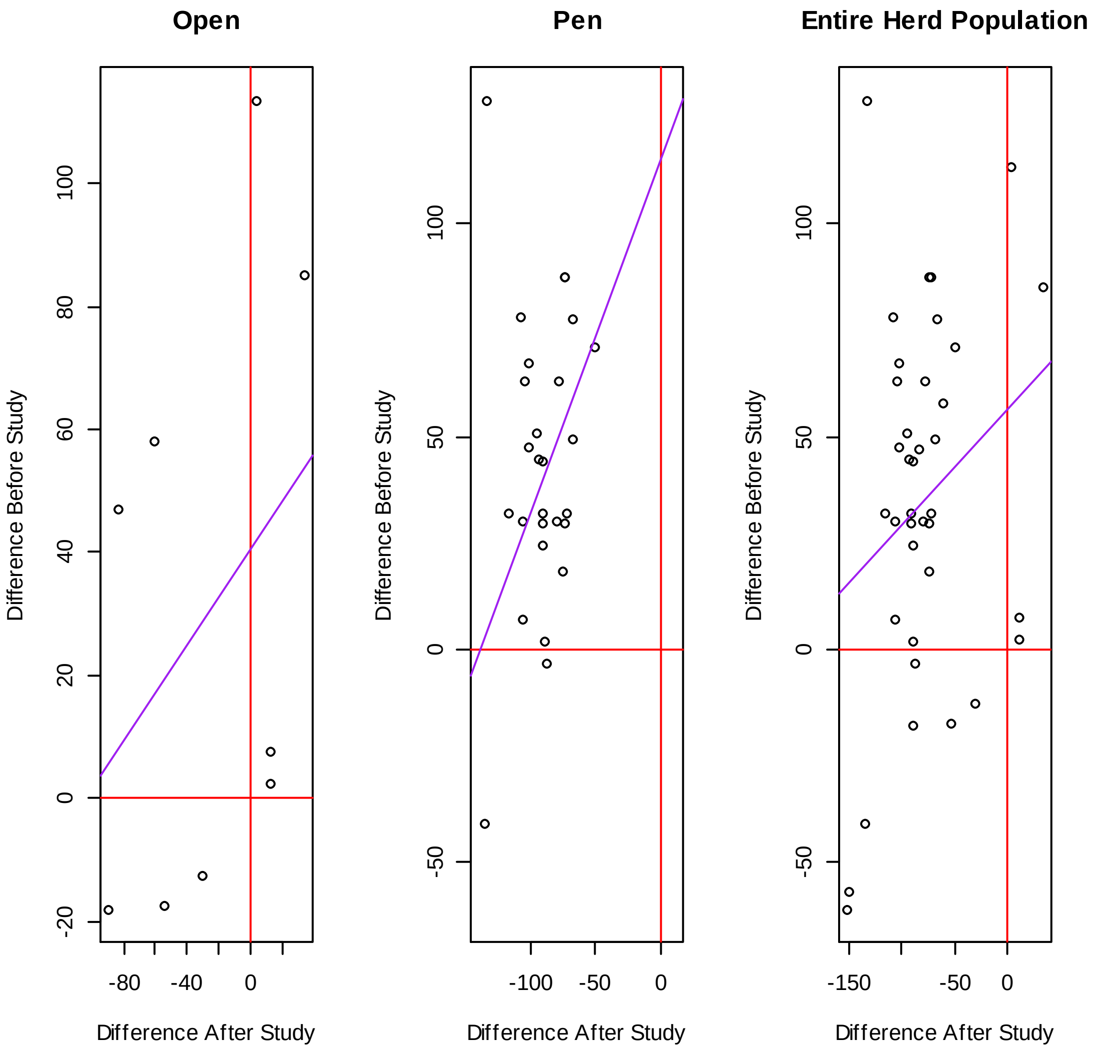

Figure 7: Weight difference in kg from the Tine recommendations before the grazing season (Y-axis) and by difference from the Tine recommended weights after the study (X-axis) by Open, Pen, and total herd population. Each heifer is represented by a dot. The horizontal red lines represent heifers that weighed the recommended weight before the study and the vertical red line represents heifers that weighed the recommended weight after the study. The purple line represents the linear trend.

After the grazing season, the significant variables of the heifers weight change included age of the heifer ($p<0.01$, T=-4.4), grazing management ($p<.05$, T=3.2) and the interaction of age of heifer and management ($p<.001$, T=3.8).

The heifers in the age group of 18-20 months of age lost on average the most weight (54.75 kg). However, the heifers in the other age groups lost on average similar amounts of weight, except the youngest heifers' age 0-12 months that lost on average 13.8 kg. In addition, the entire herd lost on average nine percent of their body weight. The heifers aged 12-14 months lost the highest percentage of their bodyweight (14%) over the summer grazing **figure 8**.

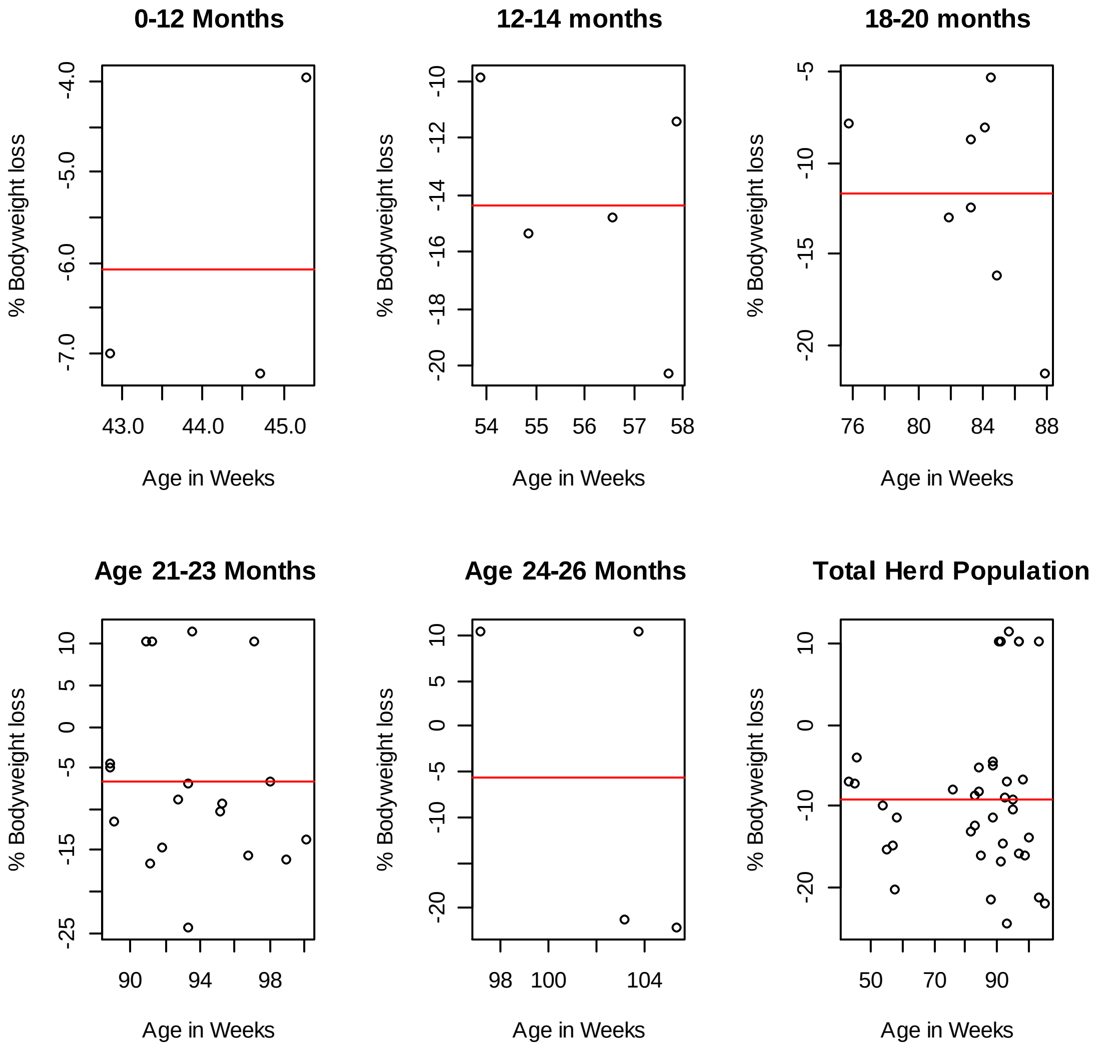

Figure 8 Percentage of body weight loss (Y-axis) of all heifers by their age in weeks (X-axis). Each heifer is represented by a dot. The red line represents the mean percentage bodyweight loss per group

All heifers (n=38) were plotted by their difference from their Tine recommended weight before the study to the percentage body weight loss **figure 9. Figure 9** shows that those heifers that weighed considerably more than the Tine recommended weight also had a higher percent body weight loss during the grazing season (p-value<.001)**.**

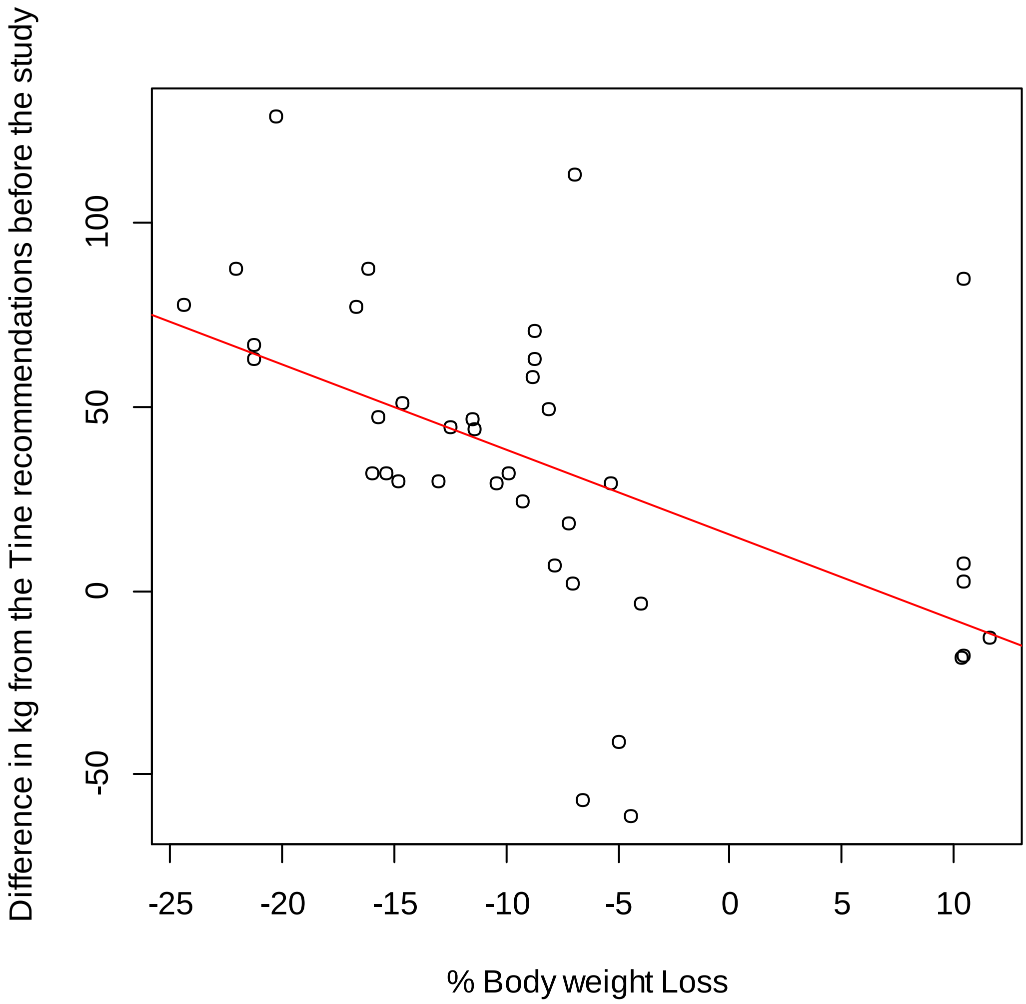

Figure 9 Difference in kg of heifers' weight from Tine's recommended weight (y-axis) and heifers' percentage body weight loss/gain (x-axis). Red line represents the linear regression line.

4. Discussion

The aim of this study was to identify if an outfield grazing production system could support heifers in their growth, body weight, and body condition in accordance to the recommendations set by Tine (2014) **Table 1.** The observed results showed that grazing management (Open management vs. Pen Management) was significant in determining heifers' weight change over the grazing season. Heifers in the O-group gained weight over the grazing season (+17.4 kg on average); in addition, those heifers were the closest to the Tine suggested body weights (28.3 kg below Tine recommended weights). Heifers in the P-group had an average weight loss of 60.9 kg and were on average 95 kg below the Tine recommended weight. Based on these results, the most likely the determining factor in the heifers' weight loss was that heifers in the P-group were restricted; and thus did not have the opportunity to consume enough forage, while heifers in the O-group did have that opportunity. Consequently, my results only partly support my initial hypothesis of heifers in both production systems being able to forage enough vegetation to meet their nutritional requirements to maintain appropriate growth pattern and body condition as recommended by Tine (2014). Unexpectedly, heifers had minimal change in body condition, even with high body weight loss. Heifers from the O-group system had an average gain of 0.03 points, while heifers from the P-group had a decrease of 0.21 points. The entire herd population had an average score of 3.52 before the study and a score of 3.37 after the study **Table 3.**

4.1 Comparison of Grazing Management Production Systems

Nutrient requirements in a grazing management system is difficult to define because it can be altered by the animals grazing activity, travel, and environmental stresses (Allison, 1985). Where cattle migrate is influenced by multiple environmental factors including vegetation type (Smith, Rodgers, Dodd, & Skinner, 1992), forage availability (Bryant, 1982; Willms, 1988), quality of forage (Cook, 1966; Kie & Boroski, 1996), topography (Mueggler, 1965; Pinchak, Smith, Hart, & Waggoner Jr, 1991) and water availability (Irving, Rutledge, Bailey, Naeth, & Chanasyk, 1995; Willms, 1990). Cattle also do not favor each outfield pasture communities equally (Asamoah, Bork, Irving, Price, & Hudson, 2003), and Arthur (1986) discovered that cattle favored grazing within upland grasslands and scrublands, and avoided forest and riparian sites unrelatedly to the time of year. When animals are in an open area or a large plot they have the predisposition to engage in longer sessions of walking compared to animals in a smaller plot. In a study by Brosh et al. (2010), cattle in large pens walked longer (10 min), and covered both greater horizontal distance (305 meters) and increased in vertical distance traveled (6.72 meters) than compared to cattle kept in smaller pens who walked on average 7.6 min, had a mean horizontal distance covered of 263 meters and vertical distance traveled of 3.56 meters in search of food. This would give the impression that those animals would have a higher energy demand due to the increased traveling for food, which would equivocate to the animals consuming more food or weight reduction. This was not compatible with the results of this study, with the only heifers gaining weight over the grazing season originating from the O-group. The heifers in the O-group were not tracked; but, there is a high probability that similar to the findings of Brosh et al. (2010) the heifers in the O-group walked further in search of forage than heifers in the P-group.

Heifers that spent the grazing season in the P-group had a decrease in live body weight of 60.9 kg over the grazing season (**figure 5**). It is common for animals to have a daily decrease of 1 to 1.5 kg during the first weeks on pasture due to loss of intestinal fill (Hessle, Nadeau, & Johnsson, 2007; Hinks, Hunter, Lowman, & Scott, 1999; Tayler, Adler, & Rudman, 1957; Wright, Russel, & Hunter, 1986). This was seen in the O-group heifers during their time grazing on infield pastures (May 22, 2015- July 1, 2015) and those heifers had an average weight loss of 5.2 kg. However after a few weeks, dietary intake resumes to normal. Heifers in the O-group gained on average 17.4 kg while on outfield pastures. This led me to the belief that the heifers in the O-group even with the increased foraging activity were able to forage enough to meet their increased energy requirement while still gaining body weight.

4.2 Weight Difference from Tine Recommendations

From the start of the study to the end of the study, the difference in the gap between the heifers' weight and the Tine recommended weight is noticeable. Before the study, heifers (n=38) were on average 35.6 kg (O-group 30 kg, P-group 36.4 kg) above their expected weight goals. After the study, O-group heifers were on average 28 kg below the Tine recommendation, and P-group heifers were on average 94.9 kg below the Tine recommendation. Only 11% of the heifers were above the Tine recommendation and those heifers all originated from the O-group. During the study, 71% of the total number of heifers went from being above their Tine recommended weight to below their Tine recommended weight **figure 7**.

As seen in **figure 9,** there is also a pattern showing that overweight heifers that were the highest above their Tine recommendation, lost the greatest percentage of their body weight over the grazing season. The percentage of body weight loss was more prominent in heifers that were heavier than their recommended Tine (2014) weight. Hessle, Dahlström, and Wallin (2011); Hinks et al. (1999) had similar results with beef heifers, heifers that were fed at a high indoor feed intensity had the most prominent weight loss on pasture. Perhaps this was due to a larger rumen and intestinal fill and also a lower herbage intake by animals that were fed at a higher indoor-feed intensity (Hinks et al., 1999; Wright et al., 1986). Heifers that ranked in the top 10 in the greatest difference between their weight and their Tine recommended weight were on average 83.8 kg above their expected weight goal before the study; and 68.4 kg below their expected weight goal at the end of the study. Those heifers on average, ranked 7th when ranked individually by highest percentage body weight loss to lowest percentage body weight loss, with the average being 14% body weight loss during the grazing season. The condition of the heifers when released onto outfield pastures in union with pasture condition provides a guide to the heifers' performance over the grazing season.

4.3 Animal Density of Pen Management System

A study by Niemelä, Huuskonen, Jaakola, Joki-Tokola, and Hyvärinen (2008) performed a study in Finland that had success of daily weight gain of crossbred beef calves. They had cow calf pairs grazing on coastal meadows; in addition, calves were offered concentrate which "was offered in small portions approximately once a week during the grazing season" (Niemelä et al., 2008). In the study, the conclusion for appropriate animal density varied between 0.41-0.66 adult per hectare to maintain the suitable sward height for biodiversity management and animal production. High animal density is not beneficial for biodiversity or livestock production (Andresen, Bakker, Brongers, Heydemann, & Irmler, 1990). Heifers in the P-group had a heifer density of 0.42 adult per hectare for Farm B and 0.35 adult per hectare for Farm C. In Farm B the animal density was within the range for suitable sward height and Farm C, the animal density was lower than Niemelä et al. (2008) conclusion. However, the heifers from both Farm B and Farm C had extensive weight loss over the grazing season. Undoubtedly, my results from the P-group heifers were drastic and those heifers lost more than the common weight loss of cattle grazing on pastures (Hessle et al., 2007; Hinks et al., 1999; Tayler et al., 1957; Wright et al., 1986). This leads me to the conclusion that it was not the animal density but rather the pasture conditions of Farm B Pasture and Farm C Pasture were not sufficient to meet the heifers' nutritional needs, which restricted the heifers' growth and development.

4.4 Forage Quantity and Quality in the Pen Pastures

Quantity in combination of quality of herbage mass in the pen pastures was possibly the most restrictive factor regarding heifer weight gain in this study. Both Pasture B and Pasture C had similar plant varieties, e.g. *Deschampsia*, *Ranunculs*, *Poa*, *Rumex*, and *Juncaceae.*

Beef cattle studies showed limited weight gain when grazing on a low sward height (below 6 cm) and when cattle graze into the late season (mid-July to early September) (Hessle et al., 2007; Spörndly, Olsson, & Burstedt, 2000). Morris, Hirschberg, Michel, Parker, and McCutcheon (1993) showed that a sward surface height of 8-10 cm in spring and 12-15 cm in autumn is needed for maximum cattle growth. Hessle et al. (2007) advocated that quantity of forage was the limiting factor in their study, suggesting that "live weight gains on pastures were most likely restricted by herbage mass and not the nutrient concentrations." Grazing into the late season combined with a low quantity of forage available in Pasture B and Pasture C could be factors that limited the heifers' intake and thus limited their gain in body weight. It would be beneficial if this study was repeated to measure sward height in Pasture B and Pasture C in spring and autumn, and measure body weights monthly to see if Pasture B and Pasture C would show different sward growth and if heifers weight would fluctuate at different parts of the grazing season, similar to Spörndly et al. (2000).

Ideally, if a heifer could forage enough, she could fulfill her nutritional requirements on low-quality forages. However, there are physical limitations of the extent of feed a ruminant can consume. Intake of stems in legumes vs. leaf material (Hendricksen, Poppi, & Minson, 1981) or grasses (Poppi, Minson, & Ternouth, 1981) is linked with shorter retention time in the rumen which is "associated with (a) an apparent higher rate of digestion of neutral detergent fiber (NDF), (b) higher rate of passage of the NDF from the rumen, and (c) higher potential digestibility of the leaf" (Poppi et al., 1981). Feeding ruminants with long and coarse forage is also associated with low voluntary feed intake (Minson, 1963; Poppi et al., 1981). Voluntary feed intake can be a factor that could have restricted the physical capacity of digestion in both the reticulum and the rumen (Allison, 1985). There is a high variability in the productivity and nutritional quality of semi-natural grasslands. According to Tallowin and Jefferson (1999) dry-matter production can ranged from <20% to 80% and metabolic energy values were 10-40% below values for intensively managed grasslands. Our heifers even if they ate until they were full, due to the large variability of nutrition on grasslands, may not have eaten enough to fulfill their daily requirement.

4.5 Management Implications

My results illustrate that those heifers in the O-group experienced weight gain over the grazing season, while the heifers in the P-group experienced weight loss. NRF heifers can thus be managed to utilize Norwegian outfield pastures, and thrive in available outfield pasture niches herby, meeting government regulations (Knutsen, 2006; Skarstad & Borgen, 2007), improving biodiversity of Norwegian outfield pastures (Farruggia et al., 2014), while preserving cultural ties to seters (Bryn & Daugstad, 2001).

In the O-group even with an average heifer weight gain, 33% of the heifers had lost weight over the grazing season. After the grazing season, the next step for those heifers that lost weight will be a period of compensatory growth, in order to make up the body weight lost during the grazing season and be the appropriate size for calving. Compensatory or catch up growth is the "physiological process whereby an organism accelerates its growth after a season of restricted development, usually due to reduced feed intake, in order to reach the weight of the animal whose growth was never reduced" (Hornick, Van Eenaeme, Gerard, Dufrasne, & Istasse, 2000). The period of growth restriction (usually 3 months for cattle (Hornick et al., 2000)) is the period that our heifers spent on outfield pastures, and thus the adaptation period will be in the autumn when heifers return to the farm. For ruminants, this adaptation period is usually around one month of higher energy intake (Hornick et al., 2000). During the refeeding period, the emission of insulin is enhanced and plasma growth hormone concentrations is high, allowing more nutrients to be channeled for growth processes and not fat deposits (Hornick et al., 2000). However, severe nutrient restriction will reduce the mature size in livestock (Berg & Butterfield, 1976; Widdowson & Lister, 1991). Ultimately, the full degree of compensatory growth depends on multiple factors such as the animals' age and breed, the harshness of feed restriction, duration of restriction, and the subsistence of diet (Hogg, 1991; Moran & Holmes, 1978; Owens et al., 1993).

Even with some heifers experiencing weight loss in the O-group, grazing on outfield pastures may still have a place in heifer rearing. With a compensatory growth period, heifers’ development may not be severely damaged and may continue to grow into strong, economically efficient dairy cattle. For heifers when calving, it is better for them to be slightly underweight than slightly overweight due to all the health risks associated with overweight heifers giving birth (Berry et al., 2007; Dairy Austraila, 2011; Ensminger, 1980; Garnsworthy, 2006; Gearhart et al., 1990; Markusfeld et al., 1997; Roche et al., 2013; Silva et al., 2002; Swanson, 1967; Treacher et al., 1986). Studies have proved that steers on low indoor feeding intensity regained more than half of their lost live weight during their recovery period on pasture (Hinks et al., 1999; Wright, Russel, & Hunter, 1989). This reinforces the idea that heifers need to be attentively managed through their growth period to meet the growth recommendations set by Tine (2014), to have best results on pastures. When heifers are overweight, they may lose more weight on pastures than those heifers that are closer in weight to the Tine recommended weights.

This leaves Norwegian farmers faced with the challenge of balancing conservation of Norwegian outfield pastures with optimizing livestock production. Furthermore, this leaves any additional responsibilities an Open grazing management production system to the farmer e.g. additional costs of GPS units, additional labor for retrieving heifers after the grazing season, and additional time locating heifers to check in on them during the grazing season. Further research in exploring NRF heifers’ development on Norwegian outfield pastures with different indoor feeding strategies, and following those heifers into their lactation to explore their development would be thought-provoking.

5. Conclusion

My study demonstrates the potential applicability of Open outfield grazing system as a management scheme to support growth and development of NRF heifers. My study concludes that the plant quality and vegetation quantity in fenced seter areas in boreal forest areas of south eastern Norwegian outlying lands were not sufficient to support growth, and development of NRF heifers; and that heifers that were given access to graze freely in the same areas had acceptable growth. The question now is how Norwegian farmers can modify their current heifer rearing management system to allow free grazing on Norwegian outfield pastures during the summer months. Also to what degree these management changes will affect the Norwegian outfield pasture ecosystem, farmers' profit, health of heifers, lactation potential, and farmers schedule, in addition to if these effects will entail positive or negative consequences for the ecosystem and the human population. Continued research of measuring NRF heifer growth and development via live weight measurements, body condition scores, measurement of production; in addition to monitoring Norwegian outfield ecosystems via pasture condition scores, sward measuring, and biodiversity of the grasslands in different areas around Norway is highly recommended. The combination of methods will provide farmers and local authorities with a strong scientific platform to evaluate the most appropriate actions.

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Appendix

Appendix I: Body Condition Score

Body Condition Score 1: Individual heifers are extremely skinny and have little fat reserve. The heifers that score a 1 have vertebral column that are prominent and sharp to the touch, hooks and pin bones are also sharp with inadequate flesh covering and a depression between the hooks and pin bones. The animal's rib cage and short ribs are clearly seen. This body condition was not noted in any of our heifers.

Body Condition Score 2: Individual vertebras on the heifer's spine were visible but not prominent. The areas of the heifer were sharp to the touch however there was more flesh covering those heifers with a score of 1. Hook and pin bones were prominent however, the depression between them was less serious when compared to a heifer with a body condition score of 1. In a condition of 2 the rib cage and short ribs are visible. See **figure 10** and **figure 11.**

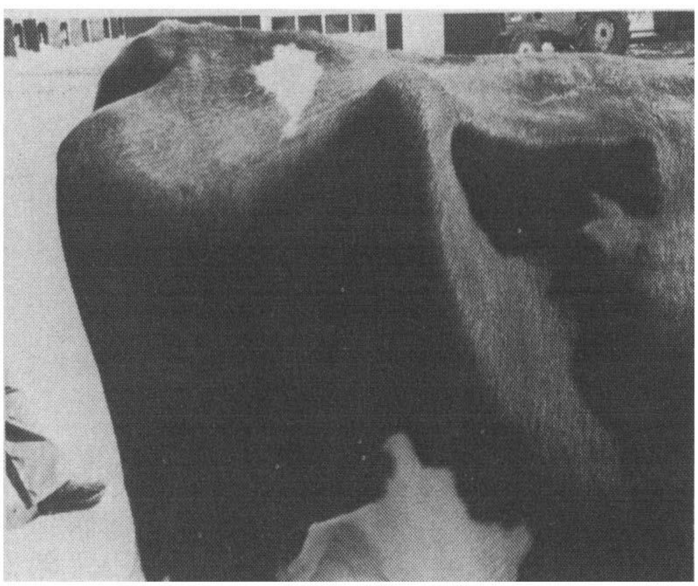

Figure 10: Side view of a cow scored condition 2. Individual spinous processes comprise the short bones that make up any shelf effect along the loin. Photo:(Wildman et al., 1982)

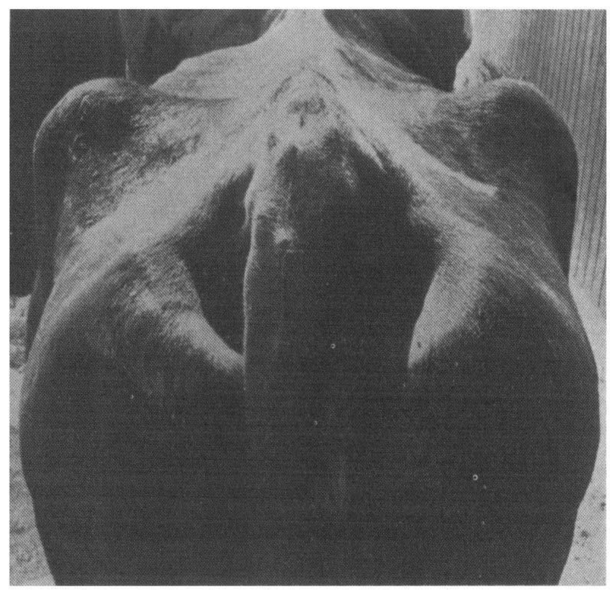

Figure 11: Rear view of the cow in Figure 1, scored condition 2. Photo:(Wildman et al., 1982)

Body Condition Score 3: In a score of 3 the heifer's bone features are apparent by applying slight pressure. There is additional fat around the short ribs and the hooks and pin bones are present but are rounded in appearance. The area between the hooks, pins and tailhead appear smooth with a negative depression between them **figure 12**, **figure 13, figure 14**.

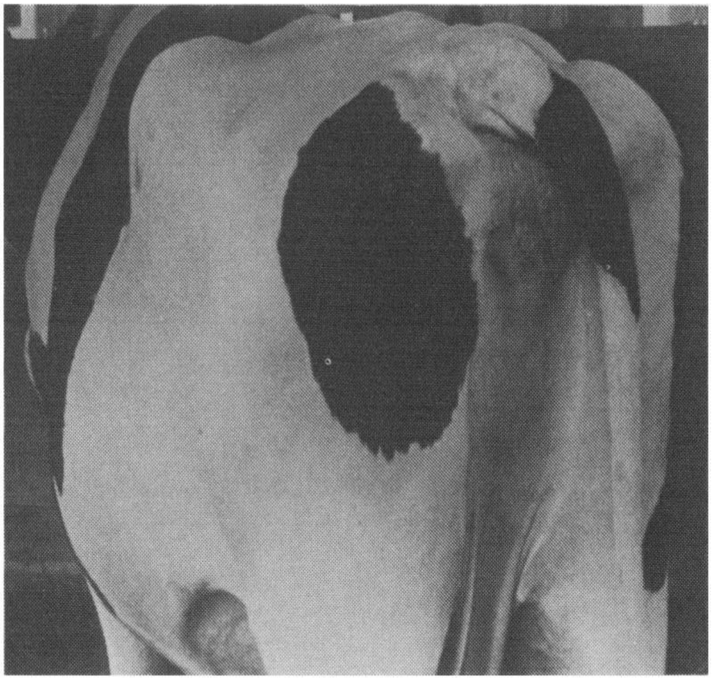

Figure 12: Side View of a cow with a body condition score of 3 Photo:(Wildman et al., 1982)

Figure 13: Rear view of a NRF cow with a body condition score of 3 (geno, s.a.)

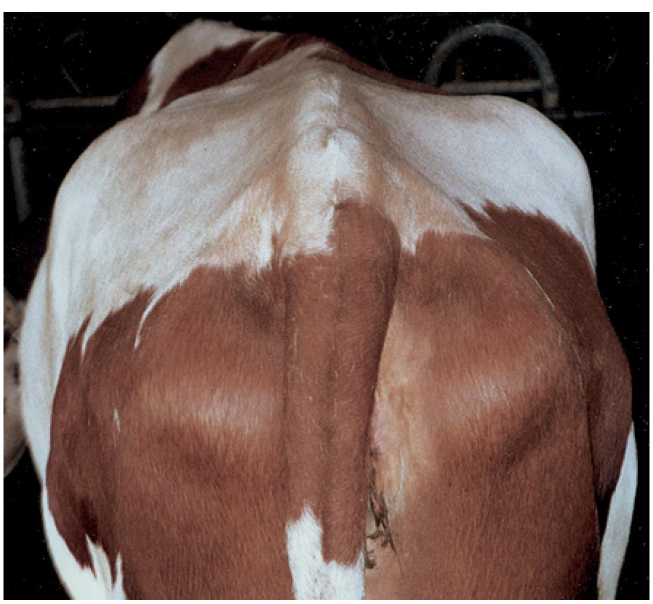

Figure 14: Rear view of a NRF cow with a body condition score of 3.5 (geno, s.a.)

Body Condition Score 4: Features of the heifer could be distinguished however, only by a firm palpation and are rounded and smooth. The appearances of the heifer's ribs are not very defined. Hooks and pins are also rounded with signs of subcutaneous fat deposits. The sacral and tailhead ligament are also not visible **figure 15, figure 16,** and **figure 17.**

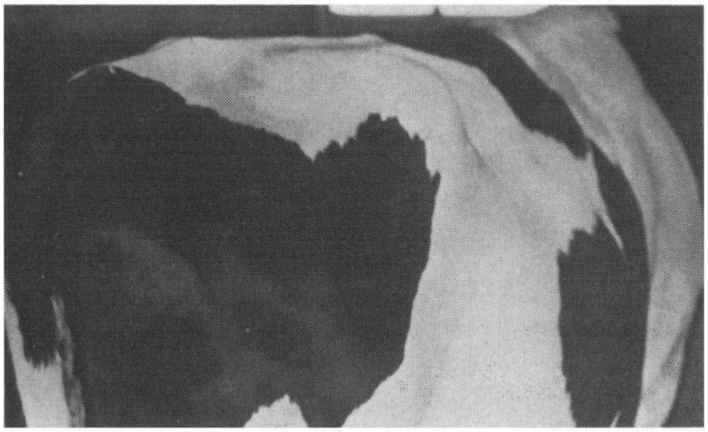

Figure 15: Body condition score of 4, ideal for drying-off Photo:(Wildman et al., 1982)

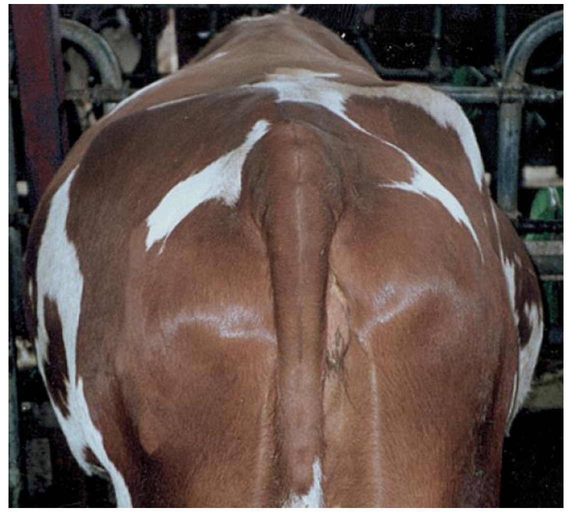

Figure 16: Rear view of a NRF cow with a score of 4 Photo: (geno, s.a.)

Figure 17: Rear view of a NRF cow with a score of 4.5 Photo: (geno, s.a.)

Body Condition Score 5: This is a very fat heifer. Bone structure of the vertebral column, hooks, and pins were not visually apparent with clear evidence of subcutaneous fat deposits. The tailhead give the impression of being submerged in fatty tissue. **Figure 18** and **figure 19**

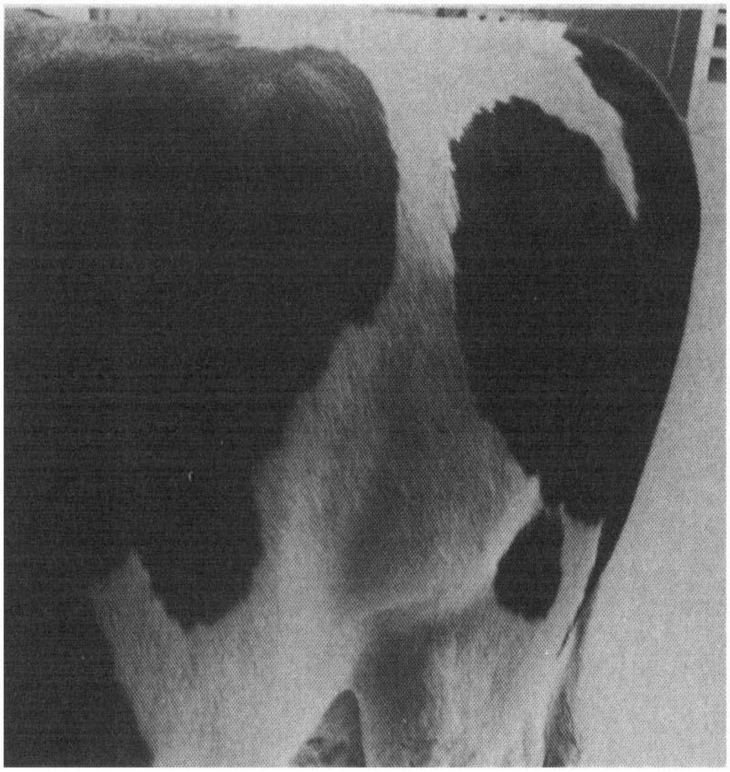

Figure 18: Side view of a cow with a score of 5
Photo:(Wildman et al., 1982)

Figure 19: Rear view of a cow with a score of 5
Photo:(Wildman et al., 1982)

Appendix II: Pasture Condition Scoresheet

Table 5: Pasture Condition Scoresheet with each category having a score between 0-4 with 4 being a score of desirable pastures with a score of 1-10 being very poor and a score of 31-40 being very good and the score for Pasture B and Pasture C during the summer of 2015. (Cosgrove, Undersander, & Davis, 1996)

Category	Farm B Pasture	Farm C Pastures
Plant Desirability: The species present are mostly: 0 1 2 3 4 Undesirable Intermediate Desirable	3	1
Plant Diversity: The diversity of plant species is: 0 1 2 3 4 Narrow<2 Medium 3-4 Broad>5	3	1
Plant Density: The percentage ground cover for desirable and intermediate species is: 0 1 2 3 4 <55 65 75 85 >95	3 About 85%	0
Plant Vigor: Desirable and intermediate species are: 0 1 2 3 4 Weak Medium Strong	1	0
Legumes in Stand: The percentage of total biomass which is legume is: 0 1 2 3 4 <10 10-19 20-29 30-39 >40	2 20%-29%	0 <10%
Severity of Use: The degree and frequency of use is: 0 2 4 2 0 Light Moderate Heavy	3	0
Uniformity of Use: The uniformity of grazing is: 0 1 2 3 4 Spotty Intermediate Uniform	2	2
Soil Erosion: Sheet, rill, gully and stream bank erosion is: 0 1 2 3 4 Severe Moderate Slight	0	0

Woody Canopy: The paddock percentage covered by a woody canopy is 0 1 2 3 4 >40 31-40 21-30 11-20 <11	0 <40%	0 <40%
Plant Residue: Dead and decaying plant material is: 0 2 4 2 0 Deficient Appropriate Excessive	2	0
Pasture Condition Score:	19	4

Appendix III: Results Parasite Testing

A total of 10 heifers (5 heifers from Farm B and 5 heifers from Farm C) were tested for microorganisms Eimeria and Stronglid type eggs. 8 heifers (4 heifers from Farm B and 4 heifers from Farm C) tested positive for one of the parasites present and only 2 heifers both originating from Farm B tested positive for both parasites present. All assessments concluded if there were parasites present they were at sparse levels **table 6.**

Table 6: Results from parasite testing from the Norwegian Veterinary Institute. 5 heifers from Farm B and 5 heifers from Farm C were tested for both Eimeria and Stonglidtype eggs from fresh fecal collection.

Cow Number	Assessment	Microorganism	Quantity
3274	Not Proven	Eimeria	Not Applicable
3274	Sparse	Stronglidtype Egg	40 Egg Per Gram
3203	Not Proven	Eimeria	Not Applicable
3203	Not Proven	Stronglidtype Egg	Not Applicable
3211	Not Proven	Eimeria	Not Applicable
3211	Sparse	Stronglidtype Egg	40 Egg Per Gram
3272	Sparse	Eimeria	40 Oocyster per Gram
3272	Not Proven	Stronglidtype Egg	Not Applicable
3227	Sparse	Eimeria	80 Oocyster per Gram
3227	Not Proven	Stronglidtype Egg	Not Applicable
850	Sparse	Eimeria	120 Oocyster per Gram
850	Sparse	Stronglidtype Egg	40 Egg Per Gram
862	Sparse	Eimeria	280 Oocyster per Gram
862	Sparse	Stronglidtype Egg	40 Egg Per Gram
865	Not Proven	Eimeria	Not Applicable
865	Not Proven	Stronglidtype Egg	Not Applicable
880	Sparse	Eimeria	40 Oocyster per Gram
880	Not Proven	Stronglidtype Egg	Not Applicable
860	Sparse	Eimeria	160 Oocyster per Gram
860	Not Proven	Stronglidtype Egg	Not Applicable

Appendix IV: Dry Weight Rank

Study Number______________________________ Date________________________Examiner: A. Gibson

Location___________________________________ Number of Quadrates______________________________

Table 7: Observation template used during vegetation analysis before the grazing season (Coulloudon, 1999)

Species	Quadrat																				Rank Tally			Weighted	% Comp
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20					

Study Number____________________________ Date________________________Examiner: <u>A. Gibson</u>

Location____Number of Quadrates______________________

Species	Quadrat																				Rank Tally			Weighted	% Comp
	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40					

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