# Performance of dairy cows and calves in agro-pastoral production systems


by

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LICENTIATE THESIS


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## Abstract

Seasonal changes in pasture quality and quantity and cattle management routines were examined on 10 farms in southwest Uganda in order to evaluate how these factors affected milk yield, live weight and body condition in cows and daily weight gain in calves in agro-pastoral production systems in a semi-arid environment.

Mean available herbage mass ranged between 0.6-1.6 ton dry matter (DM) per hectare, with the highest value found in October and the lowest in February-May. Mean metabolisable energy content in pasture ranged between 5.8-7.7 MJ/kg DM and mean crude protein content between 5.4-9.1% during the study period.

Mean daily milk yield during lactation months 0-6 was significantly higher for cows in parity ≥3 (8.7 kg) than cows in parity 2 (7.7 kg) and parity 1 (6.9 kg). Crossbreeds with >75% Holstein-Friesian (HF) and <25% Ankole had significantly higher daily milk yield (8.6 kg) than cows with 75% HF (7.7 kg) and 50% HF (6.9 kg). Cows milked twice per day had 1.9 kg higher daily milk yield than cows milked only once per day. Daily milk yield per cow decreased by 0.1-0.5 kg when dry season length increased by 10 days, with the strongest effect in early lactation. Kraaling cows at night affected milk yield negatively. Calving month and pasture availability affected cow live weight, but had no effect on body condition score and milk yield.

Daily weight gain for calves was 288, 315 and 442 g/day at age 0-2, 2-6 and 6-9 months, respectively. Average live weight for calves at age 6 and 9 months was around 90 kg and 120 kg, respectively. Daily weight gain of calves at age 6-9 months increased by 81 g for each additional percentage of crude protein in pasture ($p<0.05$). Crosses with >75% HF had 60 g lower daily weight gain than crosses with 75% HF and 25% Ankole at age 0-6 months ($p<0.05$). Birth month had no significant effect on calf weight gain.

In conclusion, the large differences in animal performance observed between farms indicate good potential for increased productivity by changing management routines. Calf growth was negatively affected by increased HF, while it had a positive impact on milk yield. This should be considered in future breeding and feeding strategies. The generally low pasture quality is most likely a limiting factor for milk productivity, as even crossbreed cows with a high inclusion of HF had only moderate milk production.



*Keywords:* Ankole, dairy crossbreed, dry season, Holstein-Friesian, management, milk yield, on-farm, pasture quality, Uganda, weight gain



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*“We shall not cease from exploration, and the end of all our exploring will be to arrive where we started and know the place for the first time.”*

T.S Eliot

# Contents

# List of Publications

This thesis is based on the work contained in the following papers, referred to by Roman numerals in the text:

I Johansson, C., Wredle, E., Mpairwe, D., Sabiiti, E. and Spörndly, E. (2013). Effects of seasonal changes and management on the growth of crossbreed calves in a semi-arid rangeland (manuscript).

II Johansson, C., Wredle, E., Katorumunda, S., Mpairwe, D., Sabiiti, E. and Spörndly, E. (2013). Effects of management and season on the performance of lactating dairy cows in agro-pastoral production systems (manuscript).

# Licentiate degree

The Licentiate degree, which requires two years of full time postgraduate study, is intended to guarantee, by means of course work and the completion of a dissertation, that the recipient

- has demonstrated an ability to investigate and to solve problems scientifically
- is conversant with general scientific methodology and is familiar with the more important research methods within his or her subject area
- is knowledgeable within his or her area of expertise and has contributed to the development of this area through his or her own research
- is able to utilize the scientific literature within the subject area and relate it to his or her research results
- has in the planning and execution of research, as well as in the analysis of results, worked both independently and in cooperation with others
- has experience in presenting and discussing research results, both orally and in writing

# Abbreviations

| | |
|---|---|
| BCS | Body condition score |
| Ca | Calcium |
| CP | Crude protein |
| DM | Dry matter |
| HF | Holstein-Friesian |
| IVOMD | In vitro organic matter digestibility |
| K | Potassium |
| LW | Live weight |
| ME | Metabolisable energy |
| Mg | Magnesium |
| N | Nitrogen |
| NDF | Neutral detergent fibre |
| P | Phosphorus |
| S | Sulphur |
| TLU | Tropical livestock units |

# 1 Introduction

Population growth in sub-Saharan Africa is among the fastest in the world, with growth rates estimated at approximately 2.5% per annum (UN, 2013a; World Bank, 2013a). However, growth in the production of livestock products is not keeping pace with the growth in the human population and sub-Saharan Africa has the lowest per capita consumption levels of livestock products in the world (Cardoso, 2012; Otte & Chilonda, 2002). In addition to the requirements of the increasing population, demand for dairy products is also increasing with rising per capita income, urbanisation and Westernisation of diets (Knips, 2006). To meet the market demand for milk and supply the population with important animal protein, cattle productivity in these areas needs to be increased. Enhancing productivity per animal rather than increasing livestock populations is necessary for rural development and poverty reduction in the developing world. It is also important with the aim of reducing greenhouse gas emissions and making improvements in environmental conditions such as preserving pasture areas (Cardoso, 2012).

The rangeland in southwest Uganda supports a high number of dairy farms. It supplies around 35% of total domestic milk production and is therefore an area of great importance for the country's dairy industry (Grimaud *et al.*, 2007). Traditionally, cattle farmers in the region mainly kept the indigenous Ankole (*Bos indicus/Bos taurus*) breed in their herds. Ankole have the ability to cope well with the harsh climate and with diseases and parasites that are common in the area. However, their milk yield is low, on average 1-2.5 litres/cow and day (Kugonza *et al.*, 2011; Galukande, 2010; Grimaud *et al.*, 2007; Hatungumukama *et al.*, 2007; Petersen *et al.*, 2003). To increase milk yield, exotic breeds, mainly Holstein-Friesian (*Bos taurus*) cattle, have been introduced and today crossbreeds of Ankole and Holstein-Friesian are a common sight in the area (Wurzinger *et al.*, 2006). Studies have shown that crossbreeding at lower levels (50 and 75%) has led to improvements in terms of higher milk yield, lower age at first calving and shorter calving intervals

(Galukande, 2010). However, these improvements are highly dependent on nutrition and management and if these are poor, the potential of high-yielding animals is not realised.

Today the population in Uganda is around 34 million, but if the annual population growth continues it will exceed 100 million by the year 2050 (UN, 2013b). This is a dramatic increase and the need for *e.g.* increased milk production is striking.

# 2 Background

## 2.1 Pastoralism

Pastoralism is the extensive grazing of rangeland for livestock production (Blench, 2001). However, pastoralism includes several different production systems and one common way to categorise these is by the degree of movement of the herds.

*Nomads* are livestock producers whose only income derives from the sale or exchange of livestock and their products. They often have established routes along which they move depending on rainfall, feed availability, diseases *etc*. A common misunderstanding is that they are travelling from place to place without a clear plan, but the truth is that they often have well-established agreements with farmers along their routes, for example regarding use of crop residues or pasture in exchange for bringing trade goods (Blench, 2001).

*Transhumant pastoralists* often move their herds between fixed points, usually to ensure feed availability for their cattle. The reason for moving the animals could of course also be water scarcity or to escape insects. It is common for transhumant pastoralists to have a permanent homestead and base where some of the family, and perhaps also some of the herd, remains throughout the year (Blench, 2001). Transhumant pastoralists exist all over the world and transport of animals by truck or train is not unusual in developed countries (Trautmann, 1985).

*Agro-pastoralists* often hold land rights and cultivate crops for household purposes and for sale. Livestock is important in their system, but their herds are often smaller than in other pastoral systems. Agro-pastoralists are often considered settled pastoralists and these groups base their production in the immediate vicinity of a permanent homestead (Blench, 2001).

### 2.1.1 Pastoralism in sub-Saharan Africa

Sub-Saharan Africa has the largest area of permanent pasture and the largest number of pastoralists of all continents (Ogle, 1996). World-wide, the pastoralists constitute one of the poorest population sub-groups (Krätli, 2001) and among the African pastoralists as many as 25-55% are classified as extremely poor (Rass, 2006). In order to meet future market demands for meat and milk as a consequence of the growing population and to reduce poverty and hunger, there is a need for these systems to increase production.

The largest populations of pastoralists and agro-pastoralists in Africa are found in Sudan and Somalia and many countries in the East African region also have the largest livestock populations (Rass, 2006). For example, in Ethiopia the livestock population is estimated to be approximately 53 million cattle and 48 million goats and sheep (FAOSTAT, 2011). The pastoral communities are most often located where conventional farming is not possible or extremely limited, and is therefore an efficient way to use the land. However, the systems are vulnerable and are facing many challenges. In particular, the rapid increase in human and livestock populations is putting high pressure on rangeland (FAO, 2013). Climate change and land conflicts are also causing problems.

### 2.1.2 Challenges for pastoralists

The single largest cause of poverty in pastoral communities is climate variability (Bagamba *et al.*, 2012; Morton, 2007). Droughts can result in severe livestock mortality, while unreliable rainfall can force pastoralists to have lower stocking rates than would be possible during more reliable weather conditions. Both these situations lead to loss of wealth and loss of potential output (Illius *et al.*, 2000).

Closely related to the climate, another major challenge for pastoralists in tropical areas is to ensure their animals have sufficient quantities of feed during the whole year (Muriuki & Thorpe, 2006). The nomads and transhumant pastoralists are becoming increasingly restricted regarding where they can move their animals in search of water and feed, due to restricted access to land. The agro-pastoralists must rely on a limited area for grazing, with limited feed resources (Thornton *et al.*, 2002), which demands good rangeland management to achieve the best possible outcome. The available pasture is decreasing during dry periods, causing drops in production. Underfeeding of animals also leads to lower growth rates and reproduction problems.

A climate with high temperatures causes rapid maturation of grass and therefore tropical pastures are often of low quality, with low protein content and low digestibility, which in turn decreases feed intake (Minson, 1990).

Depending on season, the pasture concentration of minerals also varies and in some periods this might cause mineral deficiencies for animals if they are not fed supplements that fulfil their dietary requirements.

The livestock owned by pastoralists not only act as a source of income when the meat and milk produced are sold, but also function as a capital resource. When the family needs capital, to pay school fees for example, it is very common for pastoralists to sell some of their animals, so they often keep large herds. However, having many large herds on small areas inevitably leads to overgrazing and land degradation, which can cause serious damage to rangeland (Haan *et al.*, 1997). To avoid having large herds and the associated negative impact on rangeland, productivity per animal must be increased.

In addition to all the challenges mentioned earlier, the market demand for pastoral products is increasing with the increasing population in the developing world (Steinfeld *et al.*, 2006; Delgado, 2003). This in turn is creating high demand for increasing productivity in pastoral communities.

### 2.1.3 Agro-pastoralists in southwest Uganda

The change of lifestyle from nomad to agro-pastoralist among pastoralists in southwest Uganda started back in the 1940s and is still going on (Wurzinger *et al.*, 2009). In an interview study by Wurzinger *et al.* (2009), settlement was described as a voluntary and peaceful process and many agro-pastoralists expressed satisfaction with their new lifestyle. Access to education, better availability to water, access to veterinary services and possibilities to grow crops were some of the advantages mentioned. However, they had also experienced challenges with feed availability, as they are now dependent on a limited area of land. Today, cattle are moved to other areas only during long and severe droughts, but such movement is only allowed in certain conditions and official permission is necessary. The greatest changes in lifestyle are probably having a permanent, long-lasting house and using *matoke* (cooking banana) instead of milk as a staple food.

Cattle farmers in this area traditionally kept only the indigenous Ankole breed (Figure 1), which belongs to the Sanga group (Petersen *et al.*, 2003; Mbuzza, 1995), but since the introduction of crossbreeding with Holstein-Friesian, many farmers have both pure Ankole and crossbreeds. The breeds are either kept in mixed herds or separately, with pure Ankole in one and crossbreeds in the other (Roschinsky *et al.*, 2012; Galukande, 2010; Wurzinger *et al.*, 2006). Pure Boran and Ankole-Boran crosses are kept for meat production (Wurzinger *et al.*, 2006). About 50-55% of the herd consists of cows and the remaining 45-50% of bulls and young cattle (Ocaido *et al.*, 2009a; Wurzinger *et al.*, 2008). Selection criteria for breeding of dairy cattle are mainly production traits such as milk yield and growth, but for pure Ankole the beauty of coat colour and horns also plays an important role (Wurzinger *et al.*, 2006). All cattle are given individual names based on the characteristics of sex, external appearance, ancestry *etc*. This makes it possible for farmers to trace back genealogical relationships, which is useful when it comes to breeding (Nakimbugwe & Muchunguzi, 2003).

*Figure 1.* Ankole cattle (*Bos indicus/Bos taurus*), which belong to the Sanga group. Photo by C. Johansson.

The herd is often kraaled, *i.e.* kept in a small enclosure, during the night and then taken to pasture after morning milking. The calf is used to stimulate milk let-down and is later allowed to drink the residual milk. Suckling also stimulates milk production (Orihuela, 1990). For *Bos indicus* and their crosses this phenomenon is so pronounced that they can be difficult to milk when the calf is absent (Patel & Patel, 1963). Similar behaviour has been reported for Ankole cows, which may decrease their milk production when suckling is stopped or if the calf dies (Hatungumukama *et al.*, 2007). In the evening, the animals are taken back to the kraal and lactating cows are milked a second time (Wurzinger *et al.*, 2008). According to Roschinsky *et al.* (2012), farmers with separate herds tend to let their crossbreed cattle graze on pasture which they consider to have higher quality, while pure Ankole cattle are allocated lower quality pasture. The animals are kept on pasture during the whole year, with salt as the most common supplement. Most households own land where cattle are grazed and the majority fence their land. For pasture management, bushes are often cleared and some farmers also practise bush burning, even though it is officially forbidden (Wurzinger *et al.*, 2008; Sabiiti & Teka, 2004).

Traditionally the pastoralists (often the children) looked after their animals themselves, but with the settlement process access to education increased and children were sent to school. Today, many agro-pastoralists hire labour to take care of milking, watering, herding, spraying and transport of milk (Sabiiti & Teka, 2004).

Southwest Uganda is an important area for the dairy industry since it is home to a high number of dairy farmers (Grimaud *et al.*, 2007). The average number of cattle per household is 2.11, compared with the national average of 1.37 (Sabiiti & Teka, 2004) and farms with herd size larger than 50 cattle are common (Galukande, 2010; Ocaido *et al.*, 2009a; Ocaido *et al.*, 2009b) Although crossbreeds with high levels of Holstein-Friesian blood are common, the production levels reported are quite moderate, with average milk yields of 3-7.5 kg per day (Galukande, 2010; Ocaido *et al.*, 2009b; Grimaud *et al.*, 2007). Yield is highly dependent on animal management and rangeland management and it is important to identify the management factors that are most favourable for production.

# 3 Aims of the thesis

The aims of the thesis were:

- To investigate how the quantity and quality of pasture changes during the rainy and dry season and to determine the effects of these changes on weight gain in calves and milk production in cows.
- To investigate animal management routines in agro-pastoral dairy production systems and examine how management factors affect weight gain in calves and milk production in cows.

The starting hypotheses were that:

- The quality and quantity of pasture are higher during the rainy season than during the dry season
- Milk yield in cows and weight gain in calves is negatively affected by decreased pasture quantity and quality
- Decreased pasture availability is reflected in decreased live weight and body condition score in cows
- High-grade Holstein-Friesian cross cows have higher milk yields than low-grade crosses
- High-grade Holstein-Friesian cross calves have higher growth rate than low grade crosses
- Cows that are kraaled at night have lower milk yields than cows kept on pasture at night
- Calves that spent less time with their dams have lower daily weight gain.

# 4 Materials and methods

## 4.1 Location and climate of the study area

The study was conducted during September 2011-July 2012 in the sub-counties Kazo and Rwemikoma, Kiruhura district, southwest Uganda. The study site is marked on the map in Figure 2.


*Figure 2.* Map of Uganda showing the location of the study site in Kiruhura district. Modified after (Google Maps, 2013).

The climate is semi-arid with a bimodal rainfall pattern, normally peaking from March to May and from September to November, with dry periods in between (Okello *et al.*, 2005). Based on data collected during the period 1990-2009, mean annual rainfall in the Kiruhura area is 993 mm and mean daily temperature is 23°C (World Bank, 2013b). The landscape in some areas consists of undulating hills, while in others the topography is sloping to moderately steep.

Climate data for the study period were taken from the Mbarara and Kiruhura weather stations. The data included minimum and maximum temperature (C°/day) at Mbarara and precipitation (mm/day) at Kiruhura.

## 4.2 Farms and animals

Ten dairy farms were selected with the criteria of a minimum herd size of 50 cattle and a farmer interested in participating in the study, in order to ensure the best possible conditions for data collection and dissemination of results in the farming community. The farms can be regarded as random samples of farms in Uganda that produce significant amounts for the domestic milk market and not mainly for household consumption.

The animals in the study were crossbreeds of Ankole and Holstein-Friesian. Baseline information about animal history and management were obtained by interviewing each farmer according to a structured questionnaire. Information was collected on herd structure, age of dams, parity of dams, how calves and cows were kept, how much time calves and dams were kept together daily, deworming routines, tick spraying routines, access to water, feed supplementation, salt and mineral supplementation and type of grazing system.

## 4.3 Animal measurements

Production performance was studied in terms of milk yield, body condition and weight of cows, and weight gain of their calves. Milk yield was measured using a measuring cup or a weighing scale, depending on what was most convenient for the farmer. Number of milkings per cow and day was recorded, together with the milk yield.

To compute weight gain of calves, their live weight was measured by weighing them on a weighing scale at an average interval of 23 days (range 15-33 days). At the start of the study, all calves younger than 31 days were selected and thereafter all new born calves up until January 2012 were included in the study. The total recording period included 14 farm visits.

On the occasions when the calves were weighed, cow body condition score (BCS) and weight were also recorded. BCS was visually assessed according to the nine-point scale of Nicholson and Butterworth (1986). The scoring was carried out by two individuals and the mean value was recorded. Live weight (LW) of the cow was measured with a weight measuring tape when the cow was in an upright position with forelegs together and head up, and was recorded both in cm and in kg. Where possible, the measurements were performed by the same person to reduce bias.

## 4.4 Pasture sampling

Pasture sampling was performed on nine occasions per farm between early October 2011 and mid July 2012, with an interval of 23-47 days (mean interval 35 days). Each farm was divided into three blocks based on vegetation coverage, topography and size.

During sampling, five quadrats (1.5 m x 1.5 m) were placed randomly in each block, providing 15 sampling units per farm. Due to frequent disturbance by cattle, areas near cattle handling facilities and watering points were avoided. The botanical composition was visually estimated and recorded. The above-ground biomass in the quadrat was then cut to ground level with a panga (machete) and weighed to determine fresh matter content. After weighing, samples within each block were thoroughly mixed and two subsamples of approximately 400 g from each block were kept for further analyses. In the case of pasture shortage it was not possible to obtain two subsamples per block and then only one subsample, *i.e*. all available grass, was taken.

## 4.5 Laboratory analyses

All samples were analysed for dry matter (DM), ash, neutral detergent fibre (NDF), crude protein (CP), *in vitro* organic matter digestibility (IVOMD) and minerals. Dry matter was determined according to the standard procedures of AOAC (1990), NDF using the methods described by Goering and van Soest (1970) and nitrogen (N) content according to the Kjeldahl method to obtain the crude protein content (AOAC, 1990). The *in vitro* method using rumen fluid and calculations was used to determine IVOMD and metabolisable energy (ME) (Lindgren, 1988; Lindgren, 1983; Lindgren, 1979). The mineral content (calcium (Ca), phosphorus (P), magnesium (Mg), sulphur (S) and potassium (K)) was analysed by inductive plasma-atomic emission spectroscopy (Spectro-Flame, SPECTRO Analytical Instruments, Kleve, Germany) after digestion with nitric acid according to Bahlsberg-Pålsson (1990).

## 4.6 Data treatment and statistical analyses

Statistical analysis of all data was performed using the Mixed procedure in the Statistical Analysis System (SAS version 9.2, 2008). The effects of different management and environmental factors on calf weight gain and cow milk yield, live weight and body condition during different time periods were tested. For factors with continuous variables, means were calculated to match the corresponding time period in the analysis.

In Paper I, weight gain of calves in different average age classes (0-2, 2-6 and 0-6 months) was analysed for a data set of 171 calves. Further analysis of weight gain in calves aged 6-9 months and 0-9 months was performed for 56 of the 171 calves that had completed 9 months of data recording.

In Paper II, milk yield of 153 cows was analysed up until 6 months of lactation, using the same time periods as in Paper I. A further analysis of the 98 cows that had completed 9 months of lactation was also performed for the period 6-9 months and for the entire 9-month period.

Factors that had a significant effect at $P<0.05$ were included in the final model and also tested for interactions. More details of the statistical analyses are given in Papers I and II.

A paired t-test was performed to determine whether the LW and BCS measured at the first recording in early lactation differed significantly from the values measured in lactation month 6.

# 5 Results

## 5.1 Animal management

The routines used for animal management on farm level are presented in Table 1. Cows were hand-milked with calf at foot, meaning that the calf briefly suckled the dam to stimulate milk let-down and after milking it was allowed to suckle the residual milk.

After milking, the animals were either allowed to graze together or calves and cows were separated. The animals were grazed on natural rangeland and the available grazing area ranged from 32-95 ha. All farmers performed bush clearing on their rangeland. The animals that were kraaled at night were kept on pasture for about 8-10 h per day.

No supplementary feed was given to the animals. Water was supplied by either taking the animals to a well or pond for drinking, or *ad libitum* by supplying troughs/buckets of water. Farm 7 had a cistern where water was available at all times during grazing. Farms 1, 2, 8 and 10 provided water in a trough which was always accessible during grazing and according to farmers always filled with water. Farms 3, 4, 5 and 9 took animals to a well and provided water for drinking 3 times per day. Farm 6 took animals to a well and provided water for drinking in buckets 2 times a day during the rainy season and 4 times during the dry season. There was no water in night kraals, meaning that Farms 1 and 2 were the only farms where cows could drink during night time.

All farmers protected their animals from tick-borne diseases, for example East coast fever (*Theileria parva* infection), by spraying them once per week.

Table 1. *Herd size, stocking rate, management routines, mean quality and quantity characteristics of pasture, calf growth and milk yield for the 10 farms participating in the study. TLU = tropical livestock units, DM = dry matter, ME = metabolisable energy.*

| Farm | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Herd size | 100 | 103 | 77 | 120 | 140 | 80 | 185 | 81 | 50 | 81 |
| Stocking rate (TLU/ha) | 2.1 | 2.1 | 1.7 | 1.8 | 1.8 | 3.0 | 3.7 | 2.3 | 1.2 | 1.7 |
| *Management* | | | | | | | | | | |
| Kraaling | | | | | | | | | | |
| Calves | No | Yes | Yes | Yes | Yes | No | Yes | Yes | Yes | Yes |
| Cows | No | No | Yes | No | Yes | No | Yes | Yes | Yes | Yes |
| Cow and calf together (h/day) | 12 | 1 | 1 | 7 | 4 | 2 | 8 | 6 | 1 | 1 |
| Milkings/day | 1 | 2 | 2 | 1 | 2 | 2 | 1 | 1 | 2 | 2 |
| Milking interval (h) | - | 5 | 5 | - | 4 | 8 | - | - | 4 | 6 |
| Grazing system | Free range | Free range | Rotating | Free range | Rotating | Free range | Free range | Rotating | Free range | Free range |
| Deworming /year | | | | | | | | | | |
| Calves | 12 | 6 | 2 | 1 | 12 | 4 | 2 | 1 | 2 | 3 |
| Cows | 4 | 4 | 2 | 1 | 4 | 4 | 2 | 1 | 2 | 3 |
| *Supplementation* | | | | | | | | | | |
| Salt | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Minerals | No | No | Yes | No | No | No | No | Yes | No | No |
| *Pasture* | | | | | | | | | | |
| Available pasture (kg DM/TLU) | 655 | 592 | 670 | 584 | 1084 | 441 | 144 | 372 | 1113 | 754 |
| Energy (MJ ME/kg DM) | 6.2 | 6.7 | 7.0 | 6.7 | 6.3 | 6.2 | 6.5 | 6.7 | 6.7 | 6.5 |
| Crude protein (%) | 6.2 | 6.8 | 7.9 | 7.2 | 6.6 | 6.7 | 8.7 | 7.5 | 6.7 | 7.2 |
| *Performance* | | | | | | | | | | |
| Calf growth (g/day) | | | | | | | | | | |
| Months 0-2 | 226 | 372 | 407 | 263 | 277 | 264 | 366 | 365 | 209 | 129 |
| Months 2-6 | 215 | 382 | 449 | 204 | 360 | 319 | 344 | 268 | 329 | 281 |
| Months 0-6 | 216 | 377 | 440 | 220 | 339 | 305 | 349 | 293 | 298 | 244 |
| N | 23 | 18 | 8 | 16 | 23 | 17 | 22 | 17 | 13 | 14 |
| Milk yield (kg/day) | | | | | | | | | | |
| Months 0-2 | 10.2 | 10.4 | 10.1 | 8.7 | 7.4 | 12.0 | 5.4 | 9.5 | 10.5 | 5.9 |
| Months 2-6 | 8.4 | 8.7 | 8.5 | 5.6 | 6.8 | 10.1 | 4.3 | 6.5 | 8.8 | 5.0 |
| Months 0-6 | 9.0 | 9.2 | 8.9 | 6.3 | 7.0 | 10.7 | 4.6 | 8.3 | 9.7 | 5.3 |
| N | 23 | 16 | 5 | 16 | 18 | 14 | 23 | 12 | 11 | 15 |

## 5.2 Rainfall and temperature

Rainfall normally peaks in September-November but during the work for this thesis rainfall had an early peak in August (Figure 3). January-March and June-July were the driest periods. During the study period (August 2011-July 2012), August, November and April had much higher rainfall than normal. The maximum temperature ranged from 26-30°C, with the highest temperature in January-March.

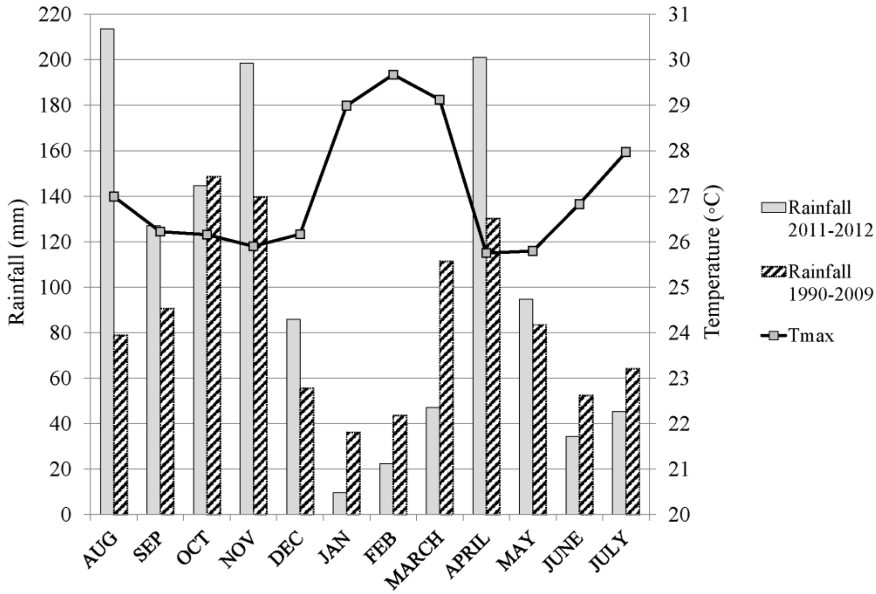


*Figure 3.* Mean monthly rainfall (Kiruhura weather station) and maximum temperature (Mbarara weather station) from August 2011 to July 2012 (study period) and mean long-term monthly rainfall (1990-2009) during the year (World Bank, 2013b).

## 5.3 Pasture quantity and quality

Species such as *Brachiaria riziziensis, B. decumbens, Hyperrhenia rufa, Kyllinga erecta* and *Sporobolus pyramidalis* were the major components of the vegetation.

The average amount of available pasture varied greatly during the study period, with a peak of 1.6 ton DM/ha in October and a minimum of ~0.7 ton DM/ha in February-May (Paper II). In addition, the differences between farms were large, with the average amount of pasture biomass ranging from 0.2-3.1 tonnes DM/ha (Paper I).

During the study period, the content of CP in pasture biomass ranged between 7-8% during the rainy season, dropped to around 5% during the dry season and then increased again, peaking in April-May (9%), when the rains returned (Figure 4). The content of energy in pasture was around 6-8 MJ ME/kg DM and NDF content ranged between 60-70% (Figure 4). Mineral content in pasture changed during the seasons and a clear decline during the dry season could be seen, especially for K, P and S (Figure 5).

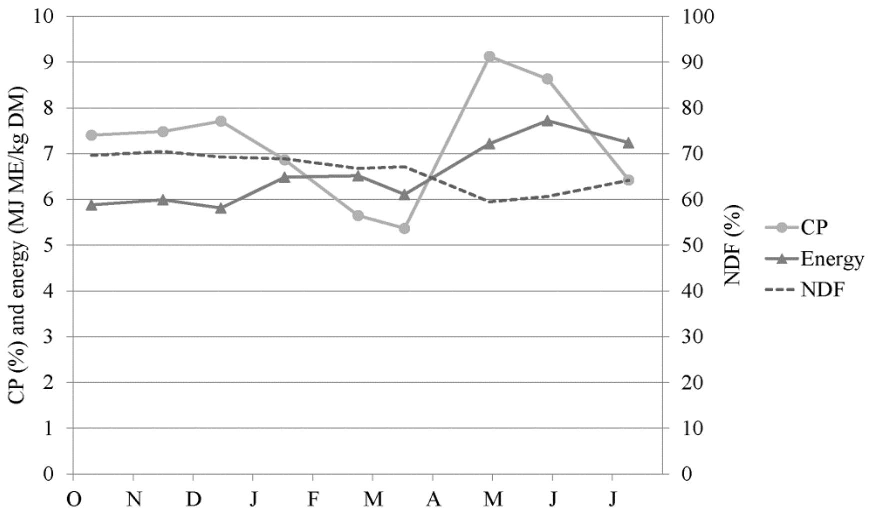


*Figure 4.* Average content of crude protein (CP), energy and neutral detergent fibre (NDF) in pasture, October 2011- July 2012.

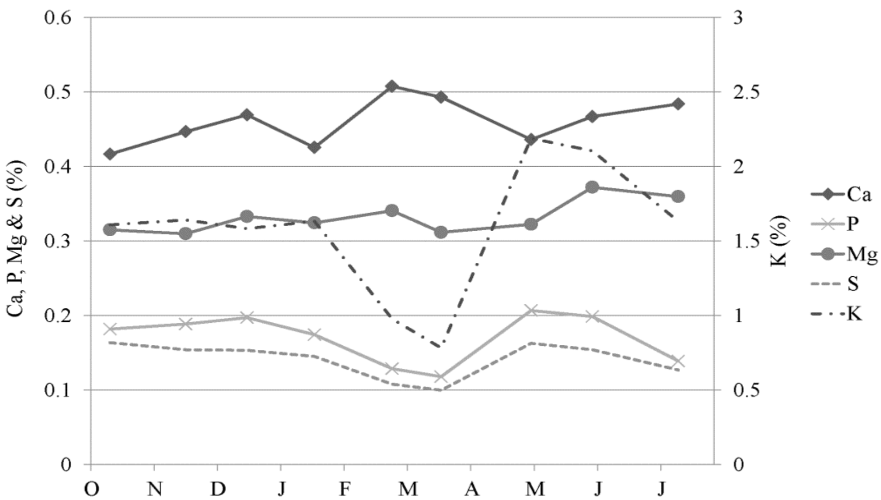


*Figure 5.* Average concentration of calcium (Ca), phosphorus (P), magnesium (Mg), sulphur (S) and potassium (K) (% on DM basis) in pasture, October 2011-July 2012.

## 5.4 Cow and calf performance

Cow lactation curves and how daily milk yield was affected by level of HF, parity and kraaling are presented in Figure 6. Cows with >75% HF had significantly higher daily milk yield (+1.5-2.3 kg) than cows with 50% HF. Cows in their third or higher parity had significantly higher daily milk yield (approx. +2 kg) than cows in their first parity. Cows that were not kraaled and had access to pasture during the night had around 1.6 kg higher daily milk yield than cows that were kraaled. Significant effects on milk yield were also found for number of milkings per day, with two milkings yielding approximately 2 kg more than a single daily milking. Furthermore, milk production was significantly lower in the dry season (Paper II).

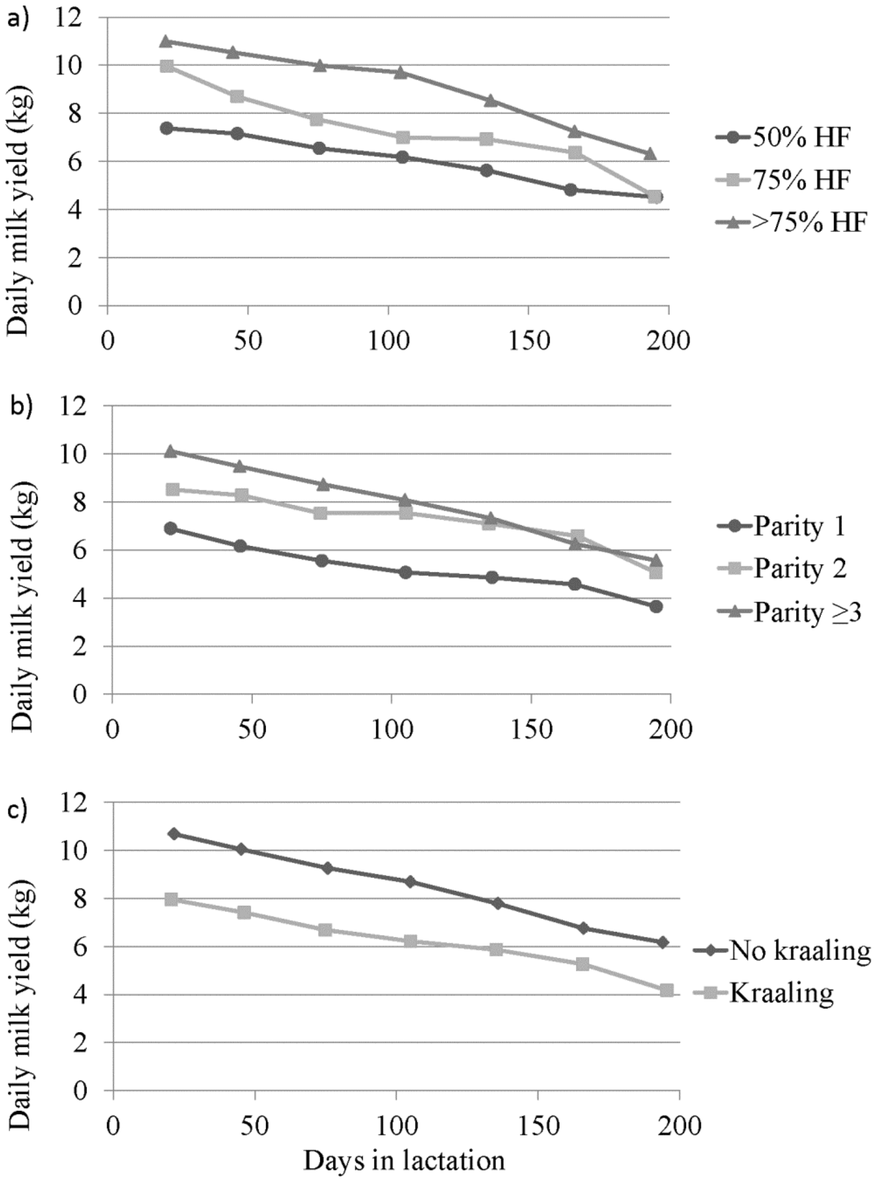


*Figure 6.* Effect of differences in a) level of Holstein- Friesian (HF), b) parity and c) kraaling on daily milk yield (see Paper II for more details). Mean values, n=153 cows.

A significant decrease ($p<0.001$) in LW (-40 kg) and BCS (-1.3 units) was seen over the first 6 months of lactation (Table 2). Cows that calved in the mid wet season kept weight better than cows that calved in the end of the rainy season. Cows also lost weight when pasture availability decreased (Paper II).

Table 2. *Live weight and body condition score (BCS) in early (month 1) and late (month 6) lactation (mean of 153 cows).The scale of BCS is from 1-9, where 1 is very thin and 9 is very fat.*

| Variable | Mean | Std. Dev | Minimum | Maximum |
|---|---|---|---|---|
| *Live weight (kg)* | | | | |
| Early lactation | $432^{a}$ | 66.0 | 248 | 669 |
| Late lactation | $395^{b}$ | 57.8 | 248 | 540 |
| *Overall p-value** | <0.001 | | | |
| | | | | |
| *Body condition score (1-9)* | | | | |
| Early lactation | $5.4^{a}$ | 0.87 | 3.0 | 7.0 |
| Late lactation | $4.1^{b}$ | 0.82 | 3.0 | 6.0 |
| *Overall p-value** | <0.001 | | | |

$^{ab}$Means within columns with different superscripts are significantly different ($p<0.05$).

The average weight gain for calves aged between 0-6 months was 308 g/day (Paper I) and live weight at 6 months was close to 92 kg (Figure 7). At 9 months of age calves weighed nearly 124 kg. Calf weight was significantly negatively affected by increased inclusion of HF blood, milking the dams only once per day and decreased CP content in the pasture. In addition, male calves had a significantly higher growth rate than female calves (Paper I).

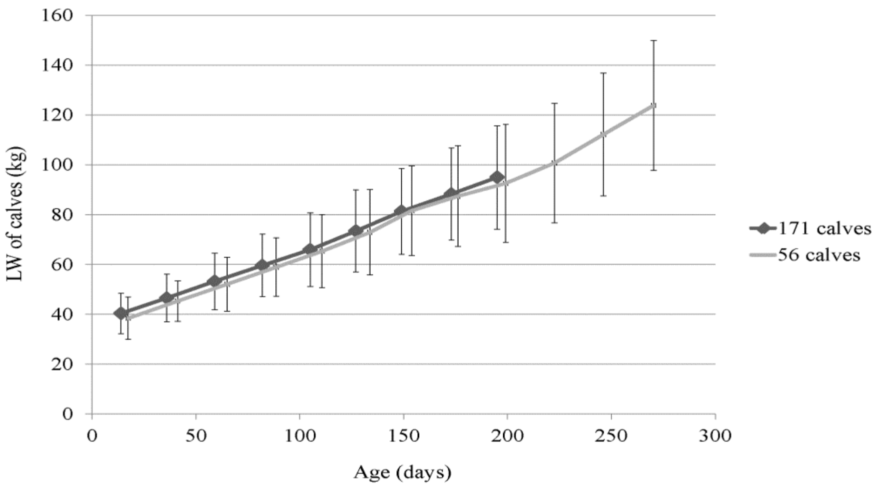


*Figure 7.* Live weight (LW) gain (mean and standard deviation) in calves aged 0-6 months (195 days, n=171) and 0-9 months (270 days n=56).

# 6 Discussion

## 6.1 Pasture and its effect on animal performance

### 6.1.1 Pasture quantity

Pasture availability varied widely throughout the study period and, in particular, was up to twice as high in the rainy season as in the dry season, in line with our hypothesis (Papers I & II). However, pasture quantity did not have the expected effect on either milk yield (Paper II) or calf growth (Paper I), contradicting those two hypotheses. When the rains returned after the dry season the grass grew quickly, with visible results in terms of increasing pasture availability after about 1-2 months (Paper II). However, in the semi-arid study area in southwest Uganda the grass also matured quickly and the nutritional value consequently decreased (Figures 4 & 5), which limits feed intake (van Soest, 1994). Since the pasture had relatively low quality during the whole study period (Paper II), it is likely that feed intake was limited and therefore there was no effect on animal performance when available pasture increased or decreased. Furthermore, some farms had extremely large amounts of available pasture (Paper II), but low animal performance (Table 1). This was presumably due to other factors such as animal material and farm-related effects, which could explain why pasture quantity was not reflected in animal performance. However, the dry season, which included a decrease in the quantity and quality of pasture and an increase in temperature, factors that all limit feed intake (West, 2003; van Soest, 1994), did have a negative effect on milk yield.

### 6.1.2 Pasture quality

The five most dominant grass species during the whole study period were *Brachiaria riziziensis, B. decumbens, Hyperrhenia rufa, Kyllinga erecta* and

*Sporobolus pyramidalis*. According to the literature (FAO, 2005), *Brachiaria riziziensis* has 7-13% CP and 55-75% digestibility and is very palatable, but needs well-drained soils and grows poorly in the dry season. *Brachiaria decumbens*, on the other hand, is described as a grass with good drought tolerance and remains green long into the dry season. *Hyperrhenia rufa* is coarse and not very palatable and has a CP content of around 4-8%. *Sporobolus pyramidalis* is described by Gambiza and Nyama (2000) as a species avoided by livestock until acceptable species have been eliminated and therefore it begins to dominate when pastures are overgrazed. The high incidence of *Sporobolus pyramidalis* in the study area is an indicator that overgrazing occurs in the area.

Although the hypothesis that the pasture quality was higher in the rainy season than in the dry season was true, the results show that the protein and energy content of the pasture was considerably higher only for a short period in the early rainy season, thereafter it declined (Figures 4 & 5). Thus the crude protein content was above 8% only during the months May and June in this study. In a similar way the energy content was above 7 MJ/kg DM during the period May-July and it was not lower in the dry period February-April than during the months October-December that were classified as rainy period. The NDF content of pasture was around 60-70%, which is slightly lower than values reported for pastures in the same area by Roschinsky *et al.* (2012) and Okello *et al.* (2005). The CP content of pasture was also similar to values reported in those studies and was below the critical value of 7% during the dry season, so it was sub-optimal for dairy production as low CP decreases feed intake and therefore has a negative impact on productivity (McDowell, 1996). The energy content of the pasture in this study ranged between 4.9-8.5 MJ ME/kg DM, which are common values in tropical pastures (Moss, 1993).

The suggested mineral requirement for lactating dairy cows is (DM basis): 0.53-0.67% Ca, 0.32-0.44% P, 0.18-0.21% Mg, 1.00-1.07% K and 0.20% S (NRC, 2001). The values found in this study were below the requirements for Ca, P, K and S, which had a minimum concentration of 0.42, 0.12, 0.78 and 0.10% of DM, respectively. Phosphorus and S were below the requirements during the whole study period, Ca during practically the whole period and K during the dry season. For P and K, the content was also below or within the critical range for ruminants (McDowell, 1985). The pasture content of Mg seemed to be satisfactory. As in the present study, a pattern of the K content in pasture being higher and the Ca content being lower in the rainy than in the dry season was previously reported in a study conducted in Ethiopia (Gizachew & Smit, 2012).

Cattle are selective grazers, which mean that they select grasses and legumes with a high nutritional value (Dumont *et al.*, 2007). Therefore it is difficult to know how much minerals, CP and energy they actually consume. However, overall nutrient consumption is limited by factors such as heat, low protein content (<7%) and increased degree of lignification (McDowell, 1996), all of which are characteristic of the pasture in the present study. In contrast to our starting hypothesis, the measured mineral, CP and energy concentration in pasture had no significant effect on milk yield (Paper II). However, milk production was moderate and, considering the nutrient quality results in the present study (Figures 4 & 5), it is likely that the poor quality of the grasses limited productivity. In order to avoid mineral deficiency and the associated effects in terms of decreased performance and health issues, it is important for farmers in these areas to provide mineral supplements for their animals. However, only two of the 10 farmers surveyed stated that they provided minerals for their animals (Table 1), while the others thought it was too expensive. To minimise the costs, one solution could be to provide extra minerals only during the dry season. However, since the concentrations of P and S in pasture were low during both the rainy and dry season (Figure 5) supplementation throughout the year is recommended.

In line with our starting hypothesis, an increased concentration of CP in pasture had a positive effect on calf growth, but only in calves aged 6-9 months (Paper I). As the CP content of the diet decreases, the digestibility also decreases (Suttie, 2000). Since high digestibility is important for calves (Moran, 2005), they might be more susceptible to changes than cows, which can explain why an effect of CP content was seen for calves but not for cows. As discussed in Paper I, many of the calves for which 6-9 months of data were available were present through the period when CP concentration in pasture peaked (May-June), which may have had a large impact on growth.

### 6.1.3 Possibilities for pasture and feeding improvements

To supply the animals with some extra feed during the dry season, one option is to conserve the excess forage in the rainy season. However, the feasibility of conserving forage from pastures to overcome shortages in the dry season has not yet been evaluated in these semi-arid agro-pastoral areas and there is a lack of knowledge about appropriate conservation techniques among the farmers. There are many challenges in conserving forage in these environments. To obtain hay or silage of good quality, the grass should be harvested in early rainy season when protein and digestibility are high. However the moisture content is also high at that time, which may cause difficulties in conservation

(Titterton *et al.*, 2000; McDonald *et al.*, 1991). Furthermore, the rainy season does not provide optimal drying conditions and storage could be difficult. If harvesting is performed at the end of the rainy season, drying conditions will be better but the quality of the grass will be poor, which may explain why hay-making is not traditional among most pastoral people in the tropics (Suttie, 2000). Silage does not require dry weather and is therefore a good option. However, these farms have large herds which require much fodder and making silage to supply that many animals would be difficult without a tractor. Therefore, silage may be more suitable for small-holder farmers today, who can handle it manually, and a future option for large-scale farming, as in the present study, when machines are available.

One way of increasing the quality of pasture could be to improve the rangeland by reseeding it with legumes or high quality grasses. Legumes tend to be richer in the major minerals, CP and energy than grasses, which would increase pasture quality (McDonald *et al.*, 2002) and possibly increase feed intake. Supplementing the diet with cereal grains and their by-products could also increase intake of minerals, for example P (McDowell & Arthington, 2005). It is also important to make sure that pasture includes species which are drought-resistant.

Shrub encroachment is a serious problem that limits production in the study area. However, bush clearing has been proven to increase pasture availability and animal performance and is highly recommended for increased productivity (Mugasi *et al.*, 2000), although it requires a lot of labour.

Pasture can also be improved by grazing management. Only three of the 10 farmers studied in Papers I and II had rotating grazing systems with paddocks (Table 1). Roschinsky *et al.* (2012) found that investment capital for establishing paddocks is scarce and rotating animals with herdsmen is becoming more difficult due to labour scarcity. Free range is probably more common, since it demands less work and investment. Roschinsky *et al.* (2012) recommend introducing rotational grazing to allow more efficient pasture utilisation. In Ethiopia, it was found that letting the pasture rest at critical stages of the growth cycle of the forage species encourages the recovery of desirable species and can therefore increase the quality of the pasture (Gizachew & Smit, 2012). In this study, the three farms with rotational grazing systems had the highest average CP content in pasture, which might indicate that rotating the animals had a positive effect on pasture quality (Table 1). As well as letting pasture rest and recover, it is also important to apply optimal grazing pressure to suppress maturation of herbage across the season (Okello *et al.*, 2005). However, a review by Briske *et al.* (2008) found no clear evidence that rotational grazing is superior to continuous grazing and therefore studies on the most appropriate method in these environments are needed before action is taken.

A paddock system with rotational grazing may also be a way to control parasites. In a study by Barger *et al.* (1994) in a tropical environment, rotationally grazed goats had lower egg counts than goats which were grazed free-range. All farmers in the present study dewormed their animals on a regular basis, some more frequently than others (Table 1), which indicates that there are problems with parasites in the area. After deworming, animals should be taken to clean pastures to avoid re-infection (Stromberg & Averbeck, 1999; Eysker *et al.*, 1998). However, this was not common practice among the farmers studied here and urgently needs to be implemented, since parasite problems are a major constraint on production in the region (Ocaido *et al.*, 2009b). However, rotational grazing must be implemented with caution, since if it is too intensive the cattle may be forced to eat all available forage and thus eat near faeces, increasing the risk of parasite infection (Stromberg & Averbeck, 1999).

With established paddocks it might also be easier to practise night grazing. Many farmers kraaled their animals at night, a practice which had a negative impact on milk yield (Paper II). A study in Nigeria showed that over 50% of total grazing time took place at night for HF cattle kept on pasture day and night, with increasing night grazing time during the dry season (Breinholt *et al.*, 1981). In Niger, night grazing is reported to have a positive effect on body condition and milk yield in cows (Ayantunde *et al.*, 2000).

## 6.2 Live weight and body condition of cows

Live weight and body condition were both lower in late lactation than in early lactation (Table 2). Cows that calved in the late rainy season had higher losses in live weight in early lactation than cows that calved in early and mid-rainy season (Paper II). The loss of weight during lactation is probably a combined effect of mobilisation of body reserves to maintain milk production and limited feed intake due to low pasture quality (Okello *et al.*, 2005). As expected, cow live weight decreased with decreasing pasture availability but, surprisingly, no effect was seen on body condition (Paper II). This may be because it takes a longer time for an effect on body condition to be seen than an effect on live weight. The live weight loss was serious (~40 kg over the first 6 months of lactation) and can have a negative impact on cow fertility, leading to longer calving intervals and thereby a loss in productivity (de Vries & Veerkamp, 2000). To avoid reproduction problems, cows that are at risk of losing weight should be fed a supplement. Another option is to control mating or use AI in order to have calving occur at a favourable time of the year. The present study was too short to allow the effects of management and season on fertility to be studied. However, the difference in weight loss between cows calving at different times of the year may have an important impact on farm finances if they significantly affect fertility (Moran, 2012). Thus this can be an important area of future research to improve these production systems

## 6.3 Effect of HF on animal performance

Increased inclusion of HF blood had a positive effect on milk yield of the cow (Paper II) and a negative impact on calf growth (Paper I). The increased milk yield was an expected result and the average milk yield was around 7-9 kg per cow and day (Paper II), with the higher values for cows with a high level of HF. Other studies in the area have reported daily milk yields in crossbreeds of around 3-7.5 kg (Galukande, 2010; Ocaido *et al.*, 2009b; Grimaud *et al.*, 2007), which is slightly lower than in the present study, probably due to the high-grade crosses included here. Compared with the potential milk yield of HF in temperate climates, the milk yields of crossbreeds in Uganda were quite moderate. Pure HF in Uganda also have moderate milk yield (7-11.7 kg per cow and day) (Grimaud *et al.*, 2007; Musoke *et al.*, 2007) and it seems to be difficult to increase yield.

Interestingly and unexpectedly, calf growth was negatively affected by increased HF (Paper I). This is probably because Ankole are better adapted to the environment, have better ability to utilise low quality forages and are less susceptible to diseases and parasites (Lagu *et al.*, 2012; Asimwe & Kifaro, 2007; Moran, 2002). Ankole cows produce milk with a higher fat content than HF cows (Mulindwa *et al.*, 2011; Petersen *et al.*, 2003). Since the effect of HF was significant in calves aged 0-2 months but not 2-6 and 6-9 months (Paper I), it is also possible that calves with more Ankole blood obtained more energy from their dam's milk than calves with less Ankole and more HF blood.

However, since it is not common practice for farmers to keep written records on their animals, the level of breed crossing was an estimate made by the farmers and the percentage levels might therefore not be exact. At farm level, it is desirable for farmers to start keeping breeding records so they can plan and control breeding for the future.

## 6.4 Effect of number of milkings on animal performance

Some farmers milked their cows only once per day due to lack of labour and difficulties with transporting milk to the cooling centre. Other farmers milked their animals twice per day, but usually with a very short interval between milkings (Table 1). For example, the first milking was commonly performed in early morning (around 5:00-8:00) and the second milking around or even before noon. These results contradict those of a previous study (Wurzinger *et al.*, 2008), in which animals in a nearby area were found to be milked in early morning and then evening. The reason for the short milking interval in the present study was mainly lack of labour. Keeping workers for late afternoon or evening milking was difficult and expensive. Farmers were also worried that if the second milking was performed too late in the day, the milk yield would be very low in the morning. The morning milking was most important for income since most of that milk was sold, whereas most of that from the second milking was kept for household purposes.

Milking twice a day gave significantly higher milk yield and also higher calf growth than milking only once a day (Papers I & II). It is known that increasing milking frequency increases milk yield (Erdman & Varner, 1995). For calves, it is possible that milking twice also meant a steady feeding routine and thus had a positive effect on daily weight gain. If labour and logistics problems could be solved, there seem to be good potential for farmers in this area to increase their milk production by increasing milking frequency and extending milking intervals. One solution for the labour problem could be to go from hand milking to bucket machine milking.

## 6.5 Differences between farms

There were large differences in the performance of animals between farms and it was difficult to determine whether one management factor was more favourable than another.

Farm 7 had the lowest milk yield of all farms but performed well in terms of calf weight gain (Table 1). One explanation for the low milk yield could be the stocking rate, which was much higher (3.7 TLU/ha) than on the other farms (1.7-3.0 TLU/ha), thereby resulting in low pasture availability for the animals, even during the rainy season. The low pasture availability probably increased the risk of parasite infections since animals had to eat all they could find, even near faeces, and the deworming interval was quite low compared with that on other farms. The animals were only milked once a day, which due to the high stocking rate was probably a good decision in order not to push the animals too much. The relatively high calf weight indicates that the diet of calves was good and it is likely that recorded milk yields were low because a lot of milk was left for the calf. These calves also spent much time with their mothers.

Farm 1 had relatively high milk yield despite only milking once per day, probably because there seemed to be enough pasture and water available. Another reason for the high milk yield could be that the animal material consisted of many high grade crosses (*i.e.* much HF) (Paper II). The daily calf growth on this farm was one of the lowest in the study. High grade crosses generally performed less well than lower grades (Paper I) and this could be one explanation for the low calf growth on Farm 1. It is also likely that these calves were not fed well, despite being together with their dams for most of the day according to the farmer. The hypothesis that weight gain is higher for calves that spent much time with their mother was thus rejected (Paper I). The reason for this is unknown.

Farm 10 had both low milk yield and low weight gain in calves. The feed availability and quality were quite similar to those on other farms, as were the management routines, but production was low. Possible explanations could be poor animal condition due to health issues and possibly non-compliance with the routine reported for providing water. Low water intake is linked to low feed intake and low milk yield in cows (Holter & Urban, 1992).

The knowledge possessed by individual farmers and the effort they devote to farming are difficult to measure, but have a major impact on production. It seemed that well-organised farms with workers who were interested and willing to do their work properly were those that performed well. The problem of finding labour is also mentioned in other studies in the same area by Alary *et al.* (2007) and Roschinsky *et al.* (2012). Well-organised farms had an owner who was present and involved in the work and it was often the son of the owner who was in charge of daily farm routines. Another feature in common for the farmers that performed well was that they all planned for and/or made investments to improve the farm. Bush clearing on the majority of land, building milking units and improving cattle crushes and watering points are some examples of investments.

In order to succeed in milk production many different factors (pasture availability, animal management, genotype *etc*.) must be taken into consideration. The farmer who manages to balance these factors well will perform well.

## 6.6 On-farm studies

On-farm studies are important since they involve farmers in the research process, which in turn facilitates the dissemination of information in rural areas. The farmers learn during the process and have a chance to influence the study. Another great advantage of on-farm studies compared with studies on a research station is that other problems which might be of importance for the present study or future studies have a better chance of being discovered.

However, the risk of on-farm studies is that they may generate information and data that are somewhat less reliable. When farmers are interviewed about their routines and management, it is possible that they will give the answer they believe to be correct rather than the true answer. Furthermore, in areas where there is no tradition of keeping records of birth/calving, breeding information and other, much of the information obtained comprises estimates made by farmers.

## 6.7 Dissemination and future research

Dissemination of research is crucial to improve farm production and farmer livelihoods. The results from the present study were disseminated and discussed at a workshop held in Kazo town in December 2012. Farmers, advisory service workers, local policymakers, teachers within the agricultural sector and others were among the participants, who were very engaged and held good discussions. During the workshop, it was concluded that farmers in the area are interested in introducing machine milking. This would lower the workload and make it easier to milk more frequently than once per day. Investigating the possibilities for introducing machine milking is one area that would be interesting for future studies. The workshop also showed the value of farmer cooperatives and how important it is to gather farmers so they can help each other, learn from each other and work together. Farmer cooperatives in the semi-arid agro-pastoral areas need strengthening.

# 7 Conclusions

Improving animal performance in livestock farming involves striking the right balance between all the variables involved; weather conditions, pasture availability, pasture quality, genotype, herd size, management *etc*. This thesis examined some of these factors and their effect on animal performance in agro-pastoral dairy production systems in southwest Uganda. Pasture was periodically of low quality and supplementation to fulfil energy, protein and mineral requirements would probably improve production performance. Milk yield was positively affected by increasing inclusion of Holstein-Friesian blood, higher parity number and milking twice per day rather than once. Milk yield was negatively affected by night kraaling and dry season. Calving month and pasture availability affected cow live weight, but had no effect on body condition score. Live weight and body condition score decreased during lactation, indicating a negative energy balance that may lead to reproduction disorders or failures. Daily weight gain of calves was negatively affected by increasing level of Holstein-Friesian blood, indicating the possibility of not meeting their nutrient requirements under the current natural pasture based feeding system and management. Calves with a high level of HF have higher nutrient requirements and are not as well adapted to the climate and environmental conditions in the tropical pastoral rangelands as calves with a higher degree of Ankole blood. This should be considered in future breeding and feeding programmes. Except for crude protein content, calf growth was not affected by changes in pasture quality and quantity, season or calving month. This is most likely due to the low quality of pasture limiting feed intake in general and to suckling forming an important part of the calf diet. The large variation in calf weight gain between farms is an indication that calf feeding and management routines on some farms can be improved.

# 8 Implications

The results presented in this thesis indicate that farmers should increase feed intake in their dairy cattle by keeping them on pasture at night. If night kraaling is necessary, the animals should be provided with access to water and preferably also feed in the kraal. To provide extra feed during the dry season, when pasture availability is scarce, techniques and methods for conservation of surplus forage in the rainy season must be investigated and implemented in the area. The content of minerals, protein and energy in pasture was found to be low. In order to increase productivity, dietary supplementation and/or pasture improvement are necessary. Farmers should not sell their cows before the third parity in order to benefit from increased milk yields and keeping crossbreeds with a high level of HF could be beneficial for milk production. Farmers could increase daily milk yield by milking twice per day rather than once, at least during the rainy season when feed and water are not scarce. When milking twice, farmers should aim for as long a milking interval as possible. With current feeding and management practices, crossbreed calves with a high level of HF blood had a lower daily weight gain than calves with a higher level of Ankole blood. It may be advantageous to start keeping breeding records for controlled breeding in the future. Live weight and body condition score were lower in late lactation than in early lactation and cows that calved in late rainy season lost more weight than cows that calved in mid rainy season. Controlled mating or use of AI could be considered for controlling calving time.

# 9 Omubigufu (summary in Runyankore)

Empinduka yeshumi namarisizo hamwe nokureeberera ente neny'ana zaazo bikashwijumwa okuruga omumarisizo ikumi (10) agari omuburengye eizoba bwa Uganda. Ekikuru kyokukyondoza kikaba kiri kwetegyereza oku eshumi nokurebera ente byaba biri kwongyera okukura kweny'ana nazanyinazo; nan'okwetegyereza yaba amate nigakanya omumarisizo agari omumyanya erimu omushana mwingi n'obunyansi bwomumarungu.

Kikahamizibwa ngu obwingi bwo bunyansi omumariisizo buri ahagati ya kilo 600-1,600 buri bishayi bibiri. Obunyansi bwingi buri oukwezi kwa Itumba (October) kandi obukye buri okuruga omukwezi kwa Biruuru (February) kuhitsya omuri Nyikoma (May).

Obwingi bw'amate niburingirira oku omuriisa arikurebeerera ente ze na'enemirundi ey'omuriisa arukukama ente ze buri eizooba. Ente eza mareeto (kuroosi) yakashatu nokukiraho (>75% kuroosi ya Friziani) nizikamwa amate maingi (Lita 8.6 bur'izooba) okukiza aza mareeto y'akabiri (Lita 7.7 burizooba) neza mareeto yokubanza (50% Friziani) ezikukamwa Lita 6.9 burizooba. Ente ezikukamwa emirundi ebiri burizooba nizikiza amate (Lita 1.9 burizooba) ezikukmwa omurundi gumwe omwizooba.

Okukura kwenyena okurugirira omubureemezi byazo kikagyenda nobunyansi bwebirisa birungi. Eki nikimanyisa ngu enyena zaza kukura kurungi zishemerire kurya obunyansi burungi. Enyena ezamaleeto zikakiza ezo ezabeire zitine shagama nyingi yezenjungu.

Okuhendere, okukyondoza oku kworekire ngu okukura kwente nenyena zaazo okurugirira omumarisizo ikumi kikahamwibwa ngu endisa nungi hamwe nokureberera enyena kwine kihango ekirikwongyera ente zaakamwa amaate mingi kandi nenyena zaazo zakura kurungi.

Ekintu kikuru munonga ekijumbwirwe okurugiriara omukukyondoza amarisizo ni ebyokurisibwa birungi ebiri omubunyansi. Obunyansi bwaba buri bubi ente tizikukamwa amaate mingi kandi nenyena tizikukuragye mangu nangwa nobuzakuuba zine eshagama nyingi yenzenjugu. Abariisa baine okureeba ngu batamu amaani maingi kureeba ngu amarisizo bagareeberera kurungi munonga ekirukurugamu kutunga amaate maingi kandii n'enyena nizikura mangu.

*Runyankore translation by Prof. E.N. Sabiiti and Dr D. Mpairwe*

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