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Philosophiae Doctor (PhD) Thesis 2011:50

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Strategies for improving dairy goat kid rearing systems for milk and meat production in Norway, Tanzania and milk utilization in Malawi

Strategiar for å betre oppalssystem for geitekje til påsett eller slakteproduksjon i Noreg og Tanzania. Bruk av geitejølk for konsum i Malawi

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Table of Contents

To my family

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PREFACE

The motivation for this study emanates from the need to increase annual milk supply to Dairies, offer alternative kid rearing systems to optimize milk yield, kid growth and increase farmers benefit in Norway and Tanzania. The study was also done to identify the missing link in the adoption of goat milk utilization for dairy goat interventions using Likoma Island in Malawi.

The work shows the significance of management strategies of Spring (March) kidding, dam kid rearing on pasture, day and night grazing system on natural pastures in the mountains, use of automatic suckling machines for Norwegians dairy goat farmers. It also shows the importance of one teat milking and one teat suckling; and once milking plus suckling for farmer's available milk for exotic dairy breed reared in the tropics. In addition, it also emphasizes the role of culture and social values of communities in goat milk utilization which is important in dairy goat interventions and other livestock interventions. Different stakeholders in the dairy goat production, utilization and promotion would benefit from this study.

Fanny Chimwemwe Chigwa

July 2011

ABBREVIATIONS

AFASS	**Acceptable, Feasible, Affordable, Sustainable and Safe replacement feeding**
AOAC	**Association of Official Analytical Chemists**
ASWAP	**Agriculture Sector Wide Approach, Republic of Malawi**
CP	**Crude Protein**
CLA	**Conjugated Linoleic Acid**
DM	**Dry Matter**
ECM	**Energy Corrected Milk**
FAO	**Food and Agriculture Organization**
GLM	**General Linear Models**
ME	**Metabolisable Energy**
NSO	**National Statistical Office of Malawi**
SAS	**Statistical Analysis System**
SCC	**Somatic Cell Counts**
UNIAIDS	**The joint United Nations Programme on HIV/AIDS**
UNICEF	**The United Nations Children's Fund**
UNIFPA	**United Nations Population Fund**
WHO	**World Health Organization**

SUMMARY/ABSTRACT

Kid rearing strategies are a key to continuous supply of milk to Dairies and reduction of kid rearing cost that will also optimize farmer's income by increasing by-products and maintaining the beautiful cultural landscape in Norway. Traditionally goats are bred for kidding around February and supply milk to Dairies according to quota. As a result of concentrated kidding, there is uneven supply to Dairies. In addition, farmers prioritize kid rearing of replacement stock and lay off the others kid at birth. Therefore, study I evaluated dam kid rearing methods on natural pasture, and also assessed the effect of increasing the grazing hours on milk yield, kid growth and milk composition. Goat behavior and feed selection pattern of dam in each of the grazing systems were also studied. To offer alternative kid rearing system, automatic suckling machines were also evaluated to increase milk supplies for goats kidding in periods of short milk supplies in study II. Unlike focusing only on kid growth, kid rearing methods need to focus on farmer's available milk.

Traditional kid suckling methods used by dairy goat farmers in Tanzania were also evaluated in Study III for farmers' available milk and kid growth. Traditional methods of one teat milking and one teat suckling twice a day; and once milking and whole day kid suckling were evaluated along with twice milking and kid bottle feeding. Though household milk utilization is the driving force for promotion of goat milk interventions for human nutrition, goat milk utilization is a challenge for goat milk interventions. Study IV was conducted on Likoma Island which has a tradition of milking local goats in Malawi to identify the missing link for goat milk utilization in goat milk interventions.

In experiment I, none suckling goats gave 42% more milk than suckling does in year 1 and 38% more in year two. Kid growth rates were similar for one and two kids reared by the dam in year

two (162g/day vs158g/day) and (172g/day vs 162g/day) in year one. While in experiment II, day and night grazing gave 14% more and higher kid growth rates. In experiment III, pre-weaning kid growth rates were higher for dam reared kids but automatic suckling gave comparable post weaning kid growth rates on pasture. In experiment IV, twice milking and bottle feeding resulted in loss of 55% of farmer's milk as compared to one teat milking and one teat suckling twice a days and 47 % loss compared to once milking and suckling whole day in year one. Similar losses were observed in year two, at 49% and 64% as compared to one teat milking and one teat suckling; and once a day milking and suckling kid whole day respectively. Finally, experiment V, showed that goat milking found its niche in a cultural context where the tea culture expresses both local identity and social motivation. Goat milk in tea enhances both the social – and nutritional – value of the tea and the cultural values within the community.

It is therefore concluded that dam kid rearing is profitable for better quality milk delivery to Dairies and labor saving on kid rearing which can offer extra income from sales of goat kids. March kidding also ensures even supply of milk to Dairies. Moreover, adopting day and night grazing for dam kid rearing on mountain pasture would optimize utilization, allow for better kid growth rates and offers high milk yield. Where farmers have lactating goats in winter, automatic suckling machine offers alternative rearing method of replacement stock which allow for high milk supplies when prices are high. In support of dairy improvement programs in the tropics, traditional suckling regimes of once a day milking offers high amounts of farmer's available milk. Where fresh supplies of milk are required for household use, one teat milking and one teat suckling is beneficial. The study also highlights the significance of cultural, social and environmental context of dairy goat interventions for sustainability and utilization of livestock interventions.

SAMMENDRAG

Ulike oppalsstrategiar for kje kan nyttast for å optimalisera tilgangen på geitemjølk til meieri, redusera oppalskostnader og opna for auka kjøtproduksjon og bruk av geit for å oppretthalda eit ope og variert kulturlandskap. Den vanlege driftsmåten i nyare tid har vore at storparten av geitene kjear i februar og dei vert mjølka til kvota er oppfylt. Dette resulterer i ujamn produksjon gjennom året. Kje som ikkje skal nyttast til rekruttering av nye mjølkegeiter, vert enten avliva ved fødsel eller slakta før dei er månadsgamle.

Dette var bakgrunnen for å gjennomføra studie I. Vi prøva ut verknad av kjeing om våren kombinert med beitebasert oppal og ulik lengd på beitetida på mjølkeavdrått og kvalitet, dagleg tilvekst hos geiter og kje samt beiteåtferd.

Når ulike oppalsmåtar skal samanliknast, er det viktig å vurdera industriens behov for mjølk og ikkje berre tilvekst hos kjea. Kunstig oppal med fri tilgang på mjølkedrikke frå automat er eit aktuelt alternativ til at kjea går med mora, særleg i periodar på året med lite mjølk. Dette alternativet er undersøkt i studie II.

Målsetjinga med studie III, var å evaluera tradisjonelle oppalsmåtar for kje i Tanzania både med omsyn til tilvekst hos kjea og tilgang på mjølk for konsum. Vi samanlikna 1) handmjølking av ein spene morgon og kveld og suging av den andre spenen med 2) mjølking berre om morgonen etter at kjea hadde vore skilde frå mora om natta, men fekk gå med om dagen og 3) eit opplegg med tildeling av mjølk frå flaske og mjølking av geitene både morgon og kveld.

Studie IV vart gjennomført på øya Likoma i Lake Malawi. I motsetnad til andre stader i Aust-Afrika, har dei lange tradisjonar med bruk av geitemjølk i hushaldet og vi ville sjå om desse erfaringane kunne vera nyttige andre stader.

I det første forsøksåret i studie I produserte geiter utan kje 42% meir mjølk enn geiter med kje og andre året var skilnaden 38%. Det var lite forskjell på tilvekst mellom einstaka og tvillingkje både første (162 og 158 g/dag) og andre året (172 og 162 g).

I studie II var avdråtten med dag- og natt-beiting 14% høgre for geiter med lengre beitetid og tilveksten til kjea var høgre begge åra i denne gruppa.

Kjea som fekk gå med mora (studie III) hadde høgre tilvekst enn kje som fekk fri tilgang på mjølkedrikke frå automat, men denne skilnaden vart delvis utjamna etter avvenning.

I studie IV vart tilgjengeleg mjølk for konsum det første året 55% lågare hos geiter som ikkje gjekk med kjea samanlikna med geiter som vart mjølka på ein spene og sogen på den andre. Skilnaden mellom geiter utan kje og geiter som vart mjølka berre om morgonen var 47%. Det andre året var desse skilnadene på 49 og 64%.

Studie V synte at det er etablert ein kulturell nisje for bruk av geitemjølk i te, både ernæringsmessig og sosialt, særleg når det er gjester på vitjing.

I arbeidet er det konkludert at godt planlagt kjeoppal er viktig for å oppnå betre mjølkekvalitet og redusert arbeidsforbruk. Kjeing om våren kombinert med at kjea går med mora er eit aktuelt tiltak for å utjamna mjølkeleveransane til meieri gjennom året og auka kjøtproduksjon på overskotskje. Det er gunstig at geitene har tilgang på beite både på dagtid og om natta. Når geitene kjear tidleg på vinteren er mjølkeleveransane til meieri ofte låge og det er difor meir aktuelt med fri tilgang på mjølkedrikke frå automat. Tradisjonelle oppalsmåtar (mjølking av ein spene) er gunstige i tropane fordi fersk mjølk vil vera lettare tilgjengeleg til ei kvar tid. Mjølking berre om morgonen er også eit svært godt alternativ. Resultata syner også at det er viktig å finna ein kulturell nisje når eit nytt produkt som mjølk skal introduserast i eit lokalsamfunn.

LIST OF MANUSCRIPTS

I. F.C. Chigwa, M. Eknæs, Ø. Havrevoll, T. Ådnoy, A. Abebe and L.O. Eik. Partial suckling and late kidding as a management tool to reduce kid rearing cost and improve distribution of goat milk to Norwegian dairies

II. F.C. Chigwa, A. Abebe, M. Eknæs, Ø. Havrevoll, T. Ådnoy and Eik L.O. Day and night grazing behavior and dam kid rearing on mountain pasture for Norwegian dairy goats

III. F.C. Chigwa, G. Steinheim and L.O Eik. A comparison of dam and machine suckling kid rearing for Norwegian dairy goats

IV. F.C.Chigwa, V. Muhikambele, T.Ådnoy and L.O. Eik . Effect of kid rearing system on farmer's available milk, milk composition and kid growth rate of pure Norwegian dairy goats reared in Tanzania.

V. F.C. Chigwa and R. Kaarhus. Social value of milking local goat on Likoma Island in Malawi: implications for livestock interventions

1. **INTRODUCTION**

1.1 Rearing of goat kids

Kids are born with no immunoglobulins in their blood; therefore transfer of passive immunity through colostrums feeding is crucial (Castro et al. 2009). Kids feeding on dam's milk grow faster than kids fed on milk replacer (Argueello et al. 2007). Kids reared on milk replacers can grow as fast as dam suckled where energy supplied by milk replacer is similar to that supplied by dam's milk. Despite being ruminants, kids are monogastrics at birth and depend on dam's milk until they can utilize solid feeds. Development of ruminant stomach for kids, depend on early exposure to hay.

Kids develop a relationship with the dam through olfactory learning process (Poindron et al. 2007a), and the role of visual and auditory stimuli are also useful (Poindron et al. 2007). As such management practices on newborn or young kids should minimize risk of rejection by its mother because visual characteristics of the young cannot compensate for loss of olfactory cues which strengthen their bond (Romeyer et al. 1994). The bond of dam and kids is also established through vocal signals like distress calls and isolation bleats emitted by kids, as they help the dam to locate the lying- out site of their kids (Poindron et al. 2003). Kids have a hiding tendency if they are grazing with the dam and vocalizations when in isolation assist the dam to locate it and consist of high pitched sneezes (Boivin & Braastad 1996; Houpt 2005; Lent 1974). Due to the hiding tendency, kids take longer to develop distress as period of separation is inhibited by nursing in between hiding periods (Addae et al. 2000). But dam-kids rearing on pasture assist kid inexperience on pasture utilization (Biquand & Biquand-Guyot 1992; Gutierrez et al. 2007).

1.2 Products and by-products in goat rearing

1.2.1 Goat Milk and meat Production in Norway

Dairy goats are reared in Norway mainly for milk production and to a small extent meat. Norwegian Dairy TINE, processes 19.7 million litres of goat milk compared to 1,500 million litres of cow's milk into more than 200 products (TINE 2011). Goat milk is seldom consumed fresh but processed into brown cheese and more into snøwfrisk cheese. All cheese is for domestic consumption and excess for selling abroad. The brown cheese is part of the traditional Norwegian diet. Production of snøwfrish cheese requires a continuous supply of milk throughout the year. Dairy goat farmers are allocated quotas to control milk supply to the Dairies. Traditionally, dairy goats are bred for kidding in around January and February each year. As soon as the quota allocation is supplied farmers do not use the milk in following lactation months, but dry off the goats. As such, there is peak milk supplies around March and June and uneven supply in end summer (August) and early winter November to December). Therefore, the dairies offer better prices of milk in periods of short supply to encourage even distribution.

Other than using goat for milk production, goats are essential in maintaining landscape. Historical landscapes in Europe are shaped by domestic animals more than crop production (Berglund 2011). Cultural mountain landscapes were formed through centuries of human use as farmers brought livestock to mountains farms to utilize the natural pastures (Herzog et al. 2005; Lunden 2004). The landscapes are maintained as goats browse and graze to transform it into a diverse mosaic of open and forest patches. Browsing is grazing of twigs (Crawley 1997), while

grazing is feeding on parts of an organism but not killing it (Begon et al. 2006). Goats are only domestic species that that browse woody species (Staaland et al. 1995). Propensity to learn what to feed on different feeds depends of past experience as goats tend to memorize feeding events (Morand-Fehr 2005). Furthermore, goat's selective feeding behavior enables goats to survive when feed is scarce and cope with toxin plants (Duncan & Young 2002). Biological diversity in the diet allow for complementary chemical interactions that help prevent toxic effects and or increase the efficiency of detoxification in small ruminants (Pontes et al. 2010). Goats can also choose their feed under free choice feeding systems according to their energy and protein needs (Fedele et al. 2002). Grazing animal also inhibit the accumulation of dead biomass through consumption of foliage and trampling (Whalley 2005). Where grazing pressure can result in formation of grazing lawns, plants are maintained in a state of continuous regeneration and therefore reduce amount of dead material in a sward (McNaughton 1984).

In addition to maintaining a cultural natural landscape, goat grazing on natural mountain pastures offers healthier dairy products in human nutrition. Milk produced under pasture based systems with adequate nutritional quality is of high in fat content because of fibre rich forages (Morand-Fehr et al. 2007). Goat milk is also high in medium chain fatty acids which are healthy and their proportion is influenced by amount of leguminous forages ingested by goats (Shingfield et al. 2008). Goat milk from pasture grazing goats is also higher in xanthophll, retinol, α-tocopherol (Lucas et al. 2008); conjugated linoleic acid (CLA) Tsiplakou et al. (2008). Therefore, milk from goats grazing on pasture is referred to as a 'nutrient stove' (Silanikove et al. 2010).

Cultural mountain landscapes have changed during the last century due to abandonment of traditional farming approaches (Antrop 2005). More and more livestock are fed in confined established pastures. As such, goat farmers reduce kid rearing costs by laying-off kids not to be used as replacement stock, and concentrate on producing milk to meet their quota allocation.

Therefore, we assessed automatic machine kid rearing, dam kid rearing with different numbers of kids on mountain pasture, different grazing systems and grazing behavior on natural pasture for milk production to ensure even annual milk production, milk yields, kid growth and somatic cell counts.

1.2.2 Goat Milk and meat Production in Tanzania

World-wide 800million goats are kept (Buerkle 2007). Goats are beneficial especially to those with limited resources (Devendra 2006). Sixty percent of the poor people's income is from livestock (Devendra 2006). Goats are preferred for their resilience and ability to produce under different conditions (Silanikove 2000). Goats of Tanzania contribute 40% of East Africa goat population (FAO 2003).

Goats are mainly kept to provide meat as a protein source in the diet and are milked by those who do not own cattle. Other species like Tanzanian short horned Zebu cattle and dairy cross-bred cattle with Bos Taurus are the major sources of milk. Local cattle breeds make 98% of the total cattle population and producing 1-2 litres a day complement milk supplies by dairy cattle (Kurwijila 1984). Literature indicate that overall, cattle supplied less than 3% of Tanzania's milk needs and 97% of the milk consumed was produced by traditional herd, Tanzanian Short-horned

Zebu (FAO 2005)). The Tanzanian livestock policy promotes smallholder dairying to meet countries milk demand (Swai & Karimuribo 2011). Smallholder dairy farmers produce only 30% of the milk produced and marketed in the country (Kurwijila 2006). Milk per capita consumption remain between 20 and 30 litres per annum which lower than Kenya's which is at 80 litres (Kurwijila 1984). Marketed milk is mainly from the dairy cattle while Zebu cattle and goat milk is mainly for household consumption and small quantities are sold (Swai & Karimuribo 2011). Low supplies of milk led to the flop of dreams by Tanzanian Dairy industries as they operated at 50% of capacity in mid 1970's and current private initiatives via tradition initiatives took over milk marketing gap (Swai & Karimuribo 2011). The Tanzanian government embarked on genetic improvement programmes to improve small holder dairying and dairy improvement programmmes could not benefit farmers milking only local goats (Mtenga & Kifaro 1992). As such, parallel dairy improvement programmed for dairy goats was initiated. Previous dairy goat breeds introduced include Kamorai in 1930 and another wave of importations was in between 1960-1980 with Sanen, Toggenburg, Anglo-nubian and Alpines (Mtenga & Kifaro 1992). Since 1988, Norwegian dairy goats have been promoted also for Tanzanian small holder farmers. The Norwegian dairy goats were introduced as a parallel effort to dairy cattle improvement programme in 1982 that was funded by NORAD. Despite the high milk yields and kid growth rates of introduced dairy goat breeds compared to local goat breeds, mortality rates of 9-54% were reported (Mtenga & Kifaro 1992). Farmers in Mgeta in Tanzania are benefitting from rearing half bred dairy goats for milk and for sell of breeding stock. Over the years dairy goat farmers have come up with innovative, traditional ways of milking dams to ensure optimal milk sharing with goat kid. The methods are one teat milking twice a day and suckling kid one teat; and once a day milking and kid suckling whole day and separating kids from does at night.

1.3 Significance of goat milk and meat

1.3.1 Nutrients in goat milk and its importance to human nutrition

Goat milk is a cradle of modern civilization in human nutrition (Hatziminaoglou & Boyazoglu 2004). In Africa goat milk is recommended for sick and weak especially by those affected by HIV/AIDS (De Vries 2008). Several studies comparing goat and cow's milk show goat milk contains 20-300mh/l oligosaccharides which is 4-5 times higher than cows' milk, 10 times higher than sheep milk but lower than human milk (Martinez-Ferez et al. 2006; Viverge et al. 1997). Amino acid profile of goat milk show that it has tauurine and glycine and glutamic acid as free amino acids (Rutherfurd et al. 2006), and taurine is 20-40 fold higher than cow's milk (Mehaila & Al-Kanhal 1992).Taurine is used in bile salt formation, calcium transport, antioxidation, central nervous system and osmoregulation (Redmond et al. 1998) and essential in infant formulas (Bouckernooghe et al. 2006). Goat milk fat globules are smaller in size in comparison to cow milk, and therefore make a softer texture (Silanikove et al. 2010).The size of fat globules range from 1 to 10 µm in both species, but fat globules of less than 5 µm in goats make 80% while only 60% in cow's milk. In addition, goat milk has a higher proportion of medium-chain fatty acids like caproic (C6:0), caprylic (C8:0) and caproic (C10:0) which are associated with 'goaty odour' of goat milk. Medium-chain fatty acids present several advantages to consumer health, but forage diets can affect fatty acid composition and bioactive lipid components in ruminant milk (Shingfield et al. 2008). Goat milk has also 62% higher linoleic acid CLA than cow's milk and CLA has anticarcinogenic and antipogenetic effect (Mc Guire and Mc Guire 2000). Goat milk has a complex array of Nucleotides NU (Prosser et al. 2008). Nucleotides facilitate immune system maturation of off-spring fed on milk; hence NU is part of infant formulas (Schallera et al. 2007). As such, infant formulas from goat milk have same levels of NU as human milk and do not need additional NU (Prosser et al. 2008). Goat milk also contains

higher content in mg/100g milk for Ca, P, K, Mg and Cl and lower for Na and Sulphur (Park 2006). Therefore, optimal sharing of goat milk between the farmers and the kid has a greater driving force as goat milk is becoming more and more important to human nutrition. In addition, where goat meat is consumed, the meat contain less fat and cholesterol than other types of meat and has desirable fatty acids because of their ability to deposit higher amount of polyunsaturated fatty acids (PUFA) than other ruminants (Koyuncu et al. 2007).

1.4 Milking frequency and effect on milk composition and quality

1.4.1Effect of milking regimes on milk composition

The main structural parts of mammary gland in ruminants include gland cistern and alveolar region. The gland cistern incorporates tortuous system of cavities into which the large ducts empty. On the other hand the alveolar is rich in milk secreting epithelium and small interlobular ducts. The gland cistern constitutes 80-90% of total udder volume in goats (Peaker & Blatchford 1988) and therefore, store milk between milkings. As such, 75% of cisternal milk is released even with 12 hours milking intervals. The large cistern is an important trait when management practices facilitate do not allow for production losses.

Literature shows bimodal or multimodal of oxytocin release at milking for goats which ensure efficient milk ejection reflex (Bruckmaier et al. 1994a). The second milk emission releases milk from the alveolar (Labussiere 1969). The second milk emission is masked in high yielding goats (Bruckmaier et al. 1994a).

Once a day milking is used as a system that combine suckling and milking. In Africa once a day milking systems is a traditional kid management system being used with introduction of dairy

goats. The dual purpose system of suckling and milking is an alternative to reduce the management cost of colostrum and bottle feeding; and improve milk yields of high yielding dams because offspring doesn't empty the udder completely (Marnet & Komara 2008; Pomies et al. 2008). Suckling also ensures release of oxytocin through mother young bond, which is inhibited in the absence of suckling (Hernandez et al. 2002). Once a day milking is also an old tradition for goat production systems in Europe (Capote et al. 1999; Salama et al. 2003). Literature reveals milk yields decreased by 26-38% with once a day milk (Boutinaud et al. 2003; Stelwagen & Knight 1997; Wilde & Knight 1990). The decrease in milk yield is lower for high yielding goats because of greater cisternal storage capacity (Marnet & Komara 2008). However, primiparous animals are more affected by once day milking because of a less developed mammary gland. Once a day milking also affect milk composition for low yielding and medium producing dairy goats, by increasing milk fat and protein unlike those producing more than 1000 L per lactation (Capote et al. 1999; Marnet & Komara 2008; Salama et al. 2003).

1.4.2 Management of goat on natural pasture and milk composition

Goats utilize fodder trees, fodder shrubs and herbaceous species for feed. Browse constitutes 50-80% of forage selected by goats all year round (Silanikove et al. 2010). Most of browse species are dicotyledons that contain tanniferous compounds, polyphenols as 50% of dry matter (Silanikove et al. 2004). Goats are able to consume 10g/day of hydrolysable tannins and 100-150g/day of condensed tannins without evidence of toxicity (Silanikove et al. 1996). Detoxification of tannins by goats is based on enzymatic hydrolysis and depolymerisation of ingested tannins (Silanikove et al. 2004). Milk produced from pasture based pasture farming systems of adequate nutritional quality is high in fat percent because of fibre rich forages, micro

components(fatty acids and vitamins), volatile compounds(flavours, terpenes), and phenolic compounds, good for human nutrition and health, hence a 'treasure stove' (Morand-Fehr et al. 2007). Grazing increases phenolic compounds in goat milk(De Feo et al. 2006; Jordan et al. 2007; Sakakibara et al. 2004). Hay diets of goats were associated with high levels of xanthophylls, retinol, α-tocopherol in Rocamadour cheese while high proportions of concentrates in the diet decreased xanthophylls and α- tocopherol content (Lucas et al. 2008). Milk and cheese from grazing goats is also of better quality parameters for human nutrition than milk from indoor fed animals in terms of quantity of cis-9 trans-11 isomers of conjugated linoleic acid (Galina et al. 2007; Tsiplakou et al. 2008).

1.4.3 Somatic cell counts and goat milk

Somatic cell count is a measure of milk quality and is used to define price of milk. Somatic cells are made up of epithelial cells, blood cells and cytoplasmic particles (Pirisi et al. 2007; Raynal-Ljutovac et al. 2007) Somatic cells occurrence in milk can be due to infections or mode of milk secretion. Milk secretion in goats is apocrine and in cows is merocrine (Raynal-Ljutovac et al. 2007). Apocrine milk secretion entails that milk will be secreted together with cytoplasmic particles. As such, the presence of non-cellular particles in goat milk make incorrect presentation of somatic cell counts as a measure of infection (Paape & Capuco 1997; Wooding et al. 1970). Healthy goats have higher somatic cell counts (Haenlein 1999). The differences in somatic cell counts for healthy cows and goats are reflected in minimum levels of cell counts set by European Union. European Union's minimum standards for somatic cell counts is 400,000,000 cell counts per milliliter for goats. Norway uses the same minimum levels and TINE has four goat milk classes depending of somatic cell counts, which has different prices. But, somatic cells occur in milk due to inflammatory process which is initiated by intra-mammary infections (Raynal-

Ljutovac et al. 2007). Bacterial infections are a major cause of variation somatic cell counts, mostly staphylococcus specie (Raynal-Ljutovac et al. 2007). In the absence of infections, somatic cells occur due to physiological processes like progress in lactation stage and estrus. As lactation stages progress somatic cell counts increase due to abrasion in mammary cells (Haenlein 2002) and similarly increases with parity (Boscos et al. 1996; Contreras et al. 1999; Rota et al. 1993). In the northern hemisphere where goat mating is photoperiod dependent, high somatic cell counts were also observed during estrus (Wilson et al. 1995). Increase in somatic cell counts have been observed with alimentary stress and vaccinations (Lerondelle et al. 1992). Somatic cell counts are also influence milk composition. High levels of somatic cell count in sheep decreased total solids (Jaeggi et al. 2003); increase soluble protein contents (Pasquini et al. 1996) and opposing facts exist for casein percentage and crude protein levels. Higher somatic cell counts in milk also reduce shelf life and lower milk stability. Shelf life of pasteurized milk of high somatic cell counts was reduced to 14 days (Rogers and Mitchell 1989). Similarly, biochemical changes due to high somatic cell counts in goat milk caused lower heat stability of milk (Manfredi et al. 2002). High somatic cell count milk may result in gelification following proteolysis via plasmin which is induced by high somatic cell counts. Plasminogen activator is heat stable and sedimentation occurs for milk high in somatic cell counts (Kelly & Foley 1997).

1.5 Milk utilization and tradition

1.5.1 Goat milk production and utilization in Norway

Society values of dairy goat milk ensure production and utilization. Traditionally, dairy goat milk produced in Norway is mainly used for making brown cheese. Brown cheese is part of the Norwegian food tradition. In 1990's brown cheese was elected as a cultural trait which is a genuine Norwegian contribution to world cuisine in a daily radio program, Nitemen (Forbord & Kvam 2002). Brown cheese, the classic G45 is made from 50% goat milk and 50% cow's milk. Some year later, brown cheese sales by TINE decreased between 1980 and 1990 (Kvam 1999) as few people below 60yrs purchase it. Changing preferences for brown cheese in 1994, made Tine to develop white (casein based) goat cheese, Snøwfrisk, half of which is sold abroad (Forbord & Kvam 2002). Brown cheese is a symbol of identity and core of society history in food habits in Norway. Despite low domestic consumption of brown cheese, a dairy company could not close down in Gudbrandsdalen community. The community lobbied for continued production of the brown Cheese, which has a name that identify with the place and valued tradition (Clemens & J. 2000). The company had to take other measures and continued to produce brown cheese. Brown cheese production, which is part of the Norwegian food tradition, is the driving force behind goat milk production although fresh milk is rarely consumed.

Use of goat milk in processed products and less domestic use when the population has alternative protein and income sources is diversification and calls for more creativity. On the other hand, failure to use few alternative protein sources when economically constrained requires and urgent need for a missing link in livestock production research. Livestock interventions that are

economically rewarding, nutritionally important but not part of social values die soon after promotion.

1.5.2 Culture and milk utilization

'Culture' has been defined as a complex whole which include knowledge, belief, art, morals, laws, customs and any other capabilities and habits acquired by man as member of a society (Tylor 1871/1974). In this context, eating can be seen as a response to both biological and cultural stimuli, and also fulfill both biological and social needs (Fieldhouse 1996). And also culture has a value system that labels bad and good food regardless of nutritional value. What people in a specific local setting can eat and drink is, of course to a large extent determined by local resources, sources of livelihoods and by household's purchasing power. But food preferences and how food is prepared and served are conditioned by culture. Cultural patterns shapes customs and practices of human food ways, such as food chosen, ways of eating, food preparation, numbers of meals per day, time for meals and size of portions eaten. Field house outlined food habits as developed and maintained because they have both social and symbolic meanings in a particular culture. He also articulates characteristics of culture which include learned experience, acquired by people as they live their everyday life; modified or unlearned; group phenomena not individuals; and ability to be transmitted from one generation to the next. Characteristics of culture imply that in the absence of socialization process culture cannot continue. The mode of socialization could be formal or informal by verbal instructions or non-verbal instructions. Each culture is not static; it preserves traditions and builds in mechanisms for change (Fieldhouse 1996). On the contrary, every society resists change and therefore changes in food habits can be difficult to change despite the ease in other cultures (Fieldhouse 1996): 2).

Social values of goat milk reveal the importance of innovations that add value to society values and norms. Technologies and innovations are likely to succeed when they reflect beliefs, norms and preoccupation of a particular culture to which they are promoted. Similar sentiments are shared in technology development. While technology development reflect the belief, norms and preoccupations of a particular cultures, technologies are made possible and limited by technologies already in use in those societies, technologies in use determine the type of technology that will be required in future(Meghani 2008):31). Meghani asserts the fact that developed technologies mirrors the concerns and beliefs of cultures within which they are created. Livestock interventions need to add value to cultural norms and values in a particular culture to ensure sustainability and continued practice beyond the project implementation period.

1.5.3 Goat production and milk utilization in Malawi

Rural populations constitute 85% of human population in Malawi, and depend mainly on agriculture for livelihood (NSO 2007). Sixty-five percent of rural households own livestock, such as cattle, goats, sheep, pigs and poultry. Goat populations show an increase per capita over the past 10 year (ASWAP 2010). Twenty four percent of those keeping livestock own goats. Distribution of goats by Agricultural Development Division (ADD), indicate the lowest numbers in Karonga ADD, followed by Salima ADD and Mzuzu ADD (Kadohira et al. 2006). Likoma district, where farmers milk local goats, falls under Karonga ADD. In Malawi as a whole, fifty-six percent of households cultivate less than 1 ha (Banda 2008), with 40% living below poverty lines in 2007(ASWAP 2010). Due to increase in human population, open land which was not suitable for crop production and earlier used for grazing is now cultivated and thus unavailable for livestock feeding. Goats however, do not require much space; they do not compete with man

for use of grain as feed but utilize small quantities of crop residues, grass and browse, unlike big animals such as cattle. Goats also fetch more cash as compared to chicken if an animal is sold. As such, goats are used as a 'bank on hoof' by poor households and as a 'nutrients stove' which uses feed not suitable for man to produce valuable products like milk and meat. Goat milking has also for a long time been practiced in communities along Lake Malawi, such as Usisya in Nkhatabay and on Likoma Island. People in these communities milk local goats. Milking local goats is actually known to be a tradition at Likoma Island.

Various livestock species have been introduced to better the lives of rural farmers. Dairy goats are being promoted in Malawi and many African countries to stimulate goat milk utilization. Among other project that promoted goat milk utilization in Malawi, was Universities Development Linkage Project(UDLP), (UDLP 1997). In particular, goat milk is being promoted for the rural poor households who cannot afford a cow, with a slogan of 'a poor man's cow'. Different dairy goat breeds were introduced in Malawi through Bunda College of Agriculture, the research station in Salima and some non- governmental organizations like Small Scale Livestock Promotion Programme (SSLPP), importations of Saanen goats and some Churches like Baptist church, Alpines. Since 1970's dairy goat improvement programmes imported *Damascus* and *Anglo Nubians* and *Saanen* from South Africa. Challenges with on-station experiments at Bunda College as regards survival of goats led to introduction of Saanen in particular, to farmers around Bunda College. Farmers were trained in goat management and utilization of goat milk as weaning food for malnourished under-five children. Farmers milked the goats during the period of project implementation. After the project implementation period, less and less farmers milked the goats, but benefitted from sales of crossbred goat kids which

fetch twice the price of local goats. Like in many projects, after the implementation period, continuity depends on the ability of the project innovation to fit into social values and household needs.

2. OBJECTIVES OF THE STUDY

The overall objective was to evaluate different strategies for improving dairy goat kid rearing systems for milk and meat production in Norway, Tanzania and milk utilization in Malawi. The specific objectives were:

1. To evaluate effect of single and twin dam kid rearing during mountain grazing on milk yield, composition and quality in goats with spring kidding to allow for continuous milk supply through-out the year and reduce kid rearing cost through dam kid rearing on mountain pasture (Study I).
2. To evaluate day grazing and day and night grazing systems for dam kid rearing on milk yield, composition and quality along with grazing behavior and feed selection pattern to optimize utilization of natural pastures(Study I).
3. To compare partial suckling and automatic suckling machines in kid rearing for replacement stock and males for meat, and post-weaning growth rates on natural pasture (Study II).
4. To investigate the effect of traditional kid suckling regimes on farmer's available milk, milk composition and kid growth rate for pure Norwegian goats reared in Tanzania (Study III).
5. To addressing the challenges of uptake of dairy goat interventions by rural poor smallholder farmers, its central element being related to goat milk utilization by studying Likoma community milking local goats in Malawi (Study IV).

3. MATERIALS AND METHODS

Three studies (I, II, III) were carried out in Norway with Norwegian dairy goats. In study I, 66 goats bred for kidding around March in 1995 and 1996. The experiment was a 2x3 factorial experiment. The dams were allocated into three groups of kid rearing of zero, one and two kids after suckling colostrums. Dams were reared in three periods of A, Spring grazing on lowland (March soon after kidding); B, natural mountain pasture grazing (June to August); and C, Autumn grazing on lowland. Half of the flock, from each of the dam kid rearing groups, was allocated to day only grazing system and day and night grazing groups. Six dams in year one and ten in year two, suckling one kid, from each grazing system were observed for behavior and feed selection. Goat behavior observations were done in parallel for 30 minutes per dam in each of the grazing systems during the day. All kids were not fed concentrate and were weaned after mountain grazing.

Study II was carried out with 120 Norwegian dairy goat kids in 2005 and 2006. The kids were allocated to dam and automatic machine kid suckling using milk replacer. Dams suckling kids were milked once while dam with kids on automatic machine were milked twice. Dam suckling kids were reared as singles. All activities in daily management of automatic suckling machine kids were recorded and also time spent. All kids had access to kid concentrate of 20% crude protein and hay ad libitum through out pre-weaning period. After weaning all kids were reared on mountain pastures to slaughter weights.

Study III was done in Tanzania using pure Norwegian goats in 2008 and 2009. In 2008, 18 lactating does kidding in June were allocated in equal numbers to three kid rearing systems while feeding in groups of two. The kid rearing systems were one teat milking and one teat suckling, twice a day; once milking plus suckling; and twice milking and kid bottle feeding separate from the dam. In 2009, 12 dams kidding from July to December were individually fed and allocated to equal groups of each of the kid suckling regimes. All kids were not fed concentrate but had access to hay throughout a pre-weaning period. All kids were weaned at 2months of age.

Study IV was involved a study of Likoma community which traditionally local goats in Malawi. Using anthropological framework, referring to local history, we analyzed current practices of milking local goats and showed how goat milking found its niche in a cultural context where tea culture expresses both local identity and social motivation. The tools used include focus group discussions with community development committees, subject specific interviews with sixteen key informants identified through snowball sampling and semi-structured interviews with 40 households milking and 40 households not milking local goats on Likoma Island.

4. MAIN RESULTS

4.1 Effects of different numbers of kids reared by dam on milk yield, quality and kid growth

None suckling goats gave more milk than suckling does in year 1(2.17kg/day versus 1.24 and 126kg/day) and two (1.98kg/day vs 1.27 and 1.23kg/day). Energy collected milk was 50% higher for non-suckling does than suckling does. Increase in number of suckling kids decreased milk butter fat% but increased lactose %. Milk protein was not significant for number of kids suckled. Kid growth rates were similar for one and two kids reared by the dam in year two (162g/day vs158g/day) and higher for single kids in year one (172g/day vs 162g/day). Therefore, dam kid rearing is profitable for better quality milk delivery to dairies and labor saving on kid rearing which can offer extra income from sales of goat kids.

4.2 Effects of grazing hours in dam kid rearing on milk yield, quality, kid growth and grazing behavior

Day and night grazing gave higher (P=0.016) milk yields in second year (1.61 vs 1.38kg/day) and kid growth (P=0.019) rate (175 vs 160g/day) in both years. Goats on day grazing only engaged in more feeding activities (62% vs 55%) during the day unlike day and night grazing flock. Feed selection behavior was similar for both grazing systems and years of experiment. Therefore, day and night grazing could be a better management tool for optimal utilization of mountain pasture. It also allows for dam kid rearing of better kid growth rates. Moreover day and night grazing offer high milk yields.

4.3 Effects of automatic suckling on pre-weaning and post-weaning kid growth rates and lactation persistence

Pre-weaning kid growth rates were higher for dam reared kids (190g/day vs 146g/day in 2005 or 184g/day vs 146g/day in 2006 and similar to automatic machine reared for post weaning on pasture(94g/day and 100g/day in 2005 and 98g/day and 93g/day in 2006). Time spent with kids on automatic machine decreased with time as kids got used to the machine. Kids reared on the machine were more stressed and attained lower growth rate by 51g/day for males and 25g/day for females. Milk yields of suckling and none suckling dams was comparable but non-suckling dam's lactation curve was more persistent.

Dam kid rearing offers optimal kid growth and better returns at selling goat kids for meat. However, automatic suckling machines offers alternative rearing method of replacement stock and goat kids for meat while allowing farmers to benefit more from winter milk sales.

4.4 Effects of traditional kid suckling system on farmers available and kid growth rates

Daily farmer's available milk was significantly higher (P=000) for Suckling goats (one teat milking plus one teat suckling, and two teat milking once a day) than none suckling (twice a day milking both teats and kids bottle fed) as 862ml for one teat milking, 731ml for once a day milking and 387ml for twice milking and artificial feeding dam's milk. Similarly, farmer's milk in experiment 1 was 875ml for one teat milking, 981 for once a day milking and 350mls for twice milking per day in experiment 2. Daily kid growth rate was not significantly different in both experiments for teat suckling and one teat milking; once a day milking and kid suckling whole day and twice milking with kids artificially fed dams milk in experiment one (73g, 66g and 62g); and experiment 2 (53g, 38g 51g).

4.5The tradition of milking local goats on Likoma and implications for livestock interventions

Social value of goat milk is embedded in the local 'tea culture' in Likoma. Referring to the local history of the tea culture, we present and analyse current practices of milking local goats, and show how goat milking found its niche in a cultural context where the tea culture expresses both local identity and social motivation. Tea is served in daily meals, during festivals and in times of food shortage. Goat milk in tea enhances both the social – and nutritional – value of the tea and the cultural values within the community. Goat milk is further preferred by poor households due to economic, as well as environmental conditions which make goat rearing suitable, as goats can survive on tree leaves in the dry season. The geographic position of the island and lack of milk storage facilities make goat milking ideal for supplying small quantities of fresh milk for daily household use. Milk goat rearing also offers protection for poorer households against uncertain fishing, in addition to small business incomes used to purchase food. Goats are acquired through farmer to farmer goat loans. Goat lending and borrowing contribute to social cohesion of the community through social capital building and farmer information exchange. Thus goat rearing enhances social networks which are glued by trust and maintained through common interests among local people.

Table 1: Effect of different kid rearing management strategies on milk yield distribution, availability and utilization and kid growth

Management strategy	Scope	Main Results	Manuscript number
Dam kid rearing on mountain pasture	Zero vs one and two kids reared by dam	-High milk yield for non suckling dams -kids growth for one or two kid rearing similar	I
Changing kidding period to Spring (March)	Persistency of milk yield lactation curve for zero, one and two kids dam reared	Lactation persistence similar for 0,1 and 2 kid dams. Therefore dam rearing reduce supply of poor quality milk to Dairies before weaning	I
Day and night grazing system on mountain pasture	Day only vs day and night grazing in dam kid rearing	-High milk yield and kid growth for dams grazing day and night -Dam kid rearing reduces kid rearing cost.	II
Use of automatic suckling machines	Dam partial kid rearing vs automatic suckling machine kid rearing	-Dam reared kids grow faster - Automatic machine reared kids compensate for growth on pasture to comparable growth rate to dam suckled kids.	III
Traditional kid rearing methods in Tanzania	One teat milking and one teat suckling twice a day; Once milking plus suckling vs Artificial rearing with dam milk	-Once milking give highest amount of farmers available milk - One teat milking and one teat milking twice a day is ideal for supply of fresh milk for household use.	IV
Study of history, current practices in goat milking community in Malawi		Cultural, social and environmental context of dairy goat interventions are a key for sustainability and utilization.	V

5. GENERAL DISCUSSION

5.1 Effects of different numbers of kids reared by the dam on milk yield, quality and kid growth

Milk yields

Number of suckling kids per dam significantly affected the milk yields for sale (P=0.0001) as shown in Table 1 and Fig 1. In experiment one, dams with zero kid gave 43% more milk for sale than dams suckling one kid and 42% more milk than dam suckling two kids. In experiment two, dams suckling zero kids gave 36% more milk than dams suckling one kid and 39% more milk than dams suckling two kids. Our results differ from Delgado-Pertnez et al.(2009), where higher milk yields were observed for dams in natural suckling group. However, our results are not comparable because our milk yield did not include what kids consumed. Kids were suckling after milking and separated from dam at night. Rearing system allowed for milking only milk that was secreted over night, taking advantage of the cisternal gland milk storage between milkings (Bruckmaier et al. 1994b; Peris et al. 1996). The alveolar milk ejection which is oxytocin mediated benefitted the suckling kids who obtained available milk. Kid rearing system had no effect on subsequent milk yields after weaning in the first lactation but the effect was prominent in second lactation. Similar results were observed when working with primiparous and multi parlous goats (Wall & McFadden 2008). Myoepethelial cell differentiation and apoptosis variations between primiparous and multiparous goats also explain the differences. On the contrary, Bar peled (1995) reported enhanced mammary development through suckling and milking because of higher proliferation and differentiation of mammary cells.

Energy collected milk during mountain grazing that was delivered to the dairy was 50% higher for dams with zero kid than dams with one kid and 59% higher than dam suckling two kids. The trend changed for post weaning energy collected milk yields, with 6% increase in energy collected milk for dam that suckled two kids than zero and one kid suckling does. On the other hand, energy collected milk in experiment two were 45% higher in none suckling dams than suckling dams of one or two kids during mountain period. After weaning, energy collected milk was 23% higher in none suckling dams than suckling dams.

Late kidding and kid suckling while grazing mountain pasture delays meeting quota allocation for milk production, allows for extra income from annual quota by supplying more milk later when the price is higher than summer, even annual distribution on milk supplies to dairies and meat production from goat kids slaughtered after mountain grazing. In Norway, goat kidding occurs in January and February and therefore dairies have peak milk quota supplies in summer (June). Milk supplies to dairies reduce becomes uneven in late fall (August) to early winter (October). Late kidding and kid suckling during mountain grazing as demonstrated in our study, delays meeting milk quota and allow for supply in periods of shortage. Moreover, Norwegian Dairy (Tine), pays farmers extra for milk supplies in early winter (Grindaker personal communication 2011), and therefore late kidding and kid suckling may increase farmers income from milk and meat of goat kids.

Other than better income from milk and even distribution of milk supply, late kidding and kid suckling will allow for meat production from goat kids slaughtered after mountain grazing. Goat kids can also be used in bush control (Baraza et al. 2009) and production of cashmere-fiber (Asheim & Eik 1998).

Dam kid rearing significantly reduced milk fat percentage (P=0.0001). Milk fat decreased with increase in number of kids reared by the dam. Dam weights indicate a decline in weight for all does on the mountain with more losses with increase in number of kid reared emphasizing the increase in nutrient requirements or suckling does though it was not significant. Along with the higher losses in weight for suckling dams, is the decrease in milk fat. The trend denoted a link between fat synthesis and maintenance energy requirements of suckling dams. As a consequence as less energy, less fat was synthesized. Unlike, several authors have reported a correlation of decrease in milk and increase in milk constituents like fat; which is explained by the effect of concentration- dilution induced by variation in milk produced (Morand-Fehr et al. 2007; Peris et al. 1997). In our study kids suckled after machine milking, therefore, suckling does appear to secrete alveolar milking when suckling the kids. Kid suckling allowed for release of oxytocin-mediated milk ejection that allowed the kids to drain alveolar milk, which has 75% of fat) than gland cistern milk that was milked by machine(Labussiere 1988). In addition, none suckling dams did not withhold any milk at milking because they did not have maternal rearing extinct observed in suckling dams. Therefore, we observed high milk fat in none suckling dams than suckling dams.

Kid live weight gains were similar for one kid and two kid dam sucking though slightly higher for single kids. The trend was observed during mountain, spring and end of autumn (Manuscript 1, Fig 2 and Table2) Therefore, our study has shown that goat kids can be reared by the dam and attain similar end weights as single reared kids. Average mountain live weight gains for one kid rearing was 167 and two kid dam rearing was 162g per day. Though the twin grew slowly during suckling period, post weaning weights indicate that twin kids could catch up with the single

reared kids. Natural rearing which was used in this study provided dam milk to all kids. Unlike where kids are reared on milk replacers which are known to have lower digestibility compared to dam milk (Sanz Sampelayo et al. 1990) and lack growth promoters (Baumrucker & Blum 1993). Natural kid rearing gave higher average daily gains compared to artificial rearing (Arguello et al. 2004; Piasentier et al. 2000) . Kids suckled milk available in the udder but possibly in differently quantities hence the differences in weight gain though not significant. Natural rearing kids gave comparable results to artificial reared kids fed on milk replacers when kids ingested feeds of similar metabolizable energy (Delgado-Pertinez et al. 2009).

5.2 Effects of day and night grazing on milk yield, kid growth and grazing behavior

Day only compared to day and night grazing

Milk yield of primiparous goats was not different for different grazing systems in pre weaning and post weaning period. In second parity, goats on day and night grazing gave more milk as compared to day grazing only both in pre-weaning and post- weaning period. The similarity in milk yield in primiparous goats was possibly because does in day grazing only compensate their nutritional requirements with the 300g increase in concentrate supplement. As such, the effect of more grazing hours was obscured by the increase in concentrate. Similar milk yields for goats exposed to naturally decreasing photoperiod and artificial photoperiod long days are also reported in literature (Flores et al. 2011). In the second year, all doe were on similar concentrate supplementation level. Increase in milk in second parity for night and day grazing could be explained by increase feeding activity as compared to day grazing only. The increase in milk yield for day and night grazing does justify day and night grazing system as a better management tool to ensure optimal feed intake on natural pastures.

Milk composition changes were more on fat and not on lactose, protein and dry matter and somatic cell count. Milk fat was high in goats grazing day time only during mountain period in primiparous goats. Decrease in milk in late lactation is associated with increase in concentration of fat due to dilution effect (Morand-Fehr et al. 2007). Moreover, day grazing only and housing in summer elevates Melatonin levels by short -day photoperiod while increase in photoperiod resulted in a decrease (Dahl et al. 2000). Melatonin is released by pineal glands during darkness and inhibits secretion of the lactational hormone, prolactin by pituitary gland. Increase in Melatonin reduces concentrations of prolactin in blood plasma, reducing milk yield and composition as to that of late lactation (Auldist et al. 1998), therefore concentration of fat increased. Seasonal variation in milk yield and composition may be due to increased amounts of circulating melatonin in shorter days of photoperiod. Concentrations of prolactin increase with increase in day light (Buchanan et al. 1993; Dahl et al. 2000; Gustafson 1994; Peters & Tucker 1978) and long day photoperiod increases milk yield (Veliz et al. 2009) . Prolactin is a peptide hormone controlling a variety of reproductive, immunological, developmental, metabolic and osmoregulatory processes (Ben-Jonathan et al. 2006; Bole-Feysot et al. 1998). Prolactin is produced by pituitary gland but secretion by other body parts is also reported in literature (Shibaya et al. 2006). At onset of lactation, prolactin conveys lipids towards mammary gland reducing their storage in adipose tissue and also affect lactose synthesis by coordinating an augmented uptake its precursor, glucose, with an increase in lactalbumin expression (Ben-Jonathan et al. 2006). In this study, we observed a significant increase in lactose in primiparous goats grazing day and night. The increase in lactose with day and night grazing could be explained by increase in prolactin with increase in photo period for day and night grazing in the Northern hemisphere where summer, grazing period, has long day light hours.

Foraging behavior for goats

Goats on day grazing only had more feeding activity than those grazing day and night in experiment one (Manuscript 2,Table4). The goats grazed more in day grazing group unlike day and night grazing. Grazing behavior of goats shows that eating start soon after sunrise and increase during the day to reach maximum before sun set, thereafter becomes almost zero most of the night (Betteridge et al. 2010). Studies on anti predator theory (Rutter 2006), sheep (Birrell 1991) heifer (Hessle et al. 2008) and beef steers (Huber et al. 1995) indicate that animals avoid grazing during darkness because of perceived risk of predation. In our study, goats in day grazing only fed more because they wanted to ingest adequate forage within day hours as they had been housed over night unlike day and night grazing group. Day and night grazing does fed less in the day because they had more feeding time at night since summer has more light hours in the northern hemisphere. Goats in day and night grazing system engaged more in non-feeding activities than those in day grazing only. Non-feeding activities for day and night grazing does were mainly standing and other social activities.

Feed selection pattern for goats

Feed selection pattern was not significant different for grazing systems (manuscript 2, Table 3). Increasing grazing hours did not change the feed selection pattern of goats probably due to high level of social organization exhibited by most ungulates species (Matteillo 2001). Social organization behavior ensure cohesion of the flock (Fraser & Broom 1990), better protection from predators and better protection of neonates and also a negative effect of competition for feed resources where they are limiting (Estevez et al. 2007).In our study, all goats had access to a vast open natural mountain pastures. Moreover, goat preference for leaves and barks highlight

their importance in bush control. Consumption of foliage and trampling by grazing animal reduce dead biomass which make the mountain prone to fire (Whalley 2005). With sufficient grazing pressure, to form grazing lawn, plants are maintained in a state of continuous regeneration (McNaughton 1984). In this study, an interaction of grazing period in the mountain and grazing system was not significant for grazing behavior and feed selection. This is may be due to the fact that the mountains were at very high altitude of 1200m above sea level and the goats accessed more and more fresh grass by going up the mountain where some snow had just melted as the forage quality was going down.

Kids reared by dams under day and night grazing grew more than those of day grazing only. Goats on day and night grazing had increased feeding activity which might be reflected in kid growth rates as observed in the study.

5.3 Effects of dam and automatic machine kid rearing on kid growth rates and lactation persistence

Dam kid rearing gave higher kid growth rate than automatic kid machine suckling. Our findings agree with kid growth rate of Creole kids and Canary kids (Arguello et al. 2004; Perez et al. 2001). Kids on auto had to cope with stress of being detached from the dam, learning to suckle teat and training to suckle independently on machine. Their stomach had to get used to artificial milk Replacer which could be cold milk for small amounts which remained in the pipes. Earlier days of machine suckling, kids had diarrhea, probably due to cold amounts of milk ingested before fresh warm milk is sucked from the milk mixer. Diarrhea was also observed in the last days on the suckling machine as kids ingested too much milk of the automatically reconstituted milk. Unlike dam suckling, where kid stop suckling when the udder is empty; kids on automatic machine could suckle as much as possible. As kid grew, intake of milk was increased at the

expense of rumen space for grass hay and concentrate that was offered adlib resulting in scours. High milk replacer intake resulted in stomach upset and diarrhea. Diarrhoea condition which result from high intake of milk replacer causes metabolic acidosis. Metabolic acidiosis promote weight loss and not weight gain in humans and calves (Berkemeyer 2009; Vajda et al. 2007). Diarrhoea in kids increase Na+ and Cl- and increase K+ along with increase in Aspartate aminotransferase (AST) (Sobiech et al. 2005).Changes in the acid base balance, damage of muscles as indicated by increase in AST seem to explain the low growth rates when kids have diarrhea. In addition to scours, low kid growth rates could also be explained by lack of growth promoters in milk replacers as compared to dam's milk (Baumrucker & Blum 1993). Milk replacers also have lower digestibility than dam's milk, which in turn result in low growth rate for kids reared on milk replacers (Sanz Sampelayo et al. 1990). These findings are different from those by (Keskin 2002), who reported no significant results and Schiessler et al., (2002) when working with Damascus goats and calves respectively where milk replacer had similar energy to dam's milk. The findings are similar to Louca et al., (1975), who reported a low growth rate of artificially reared kids weaned at 35 days as compared to 70 days when working with Damascus goats. The low growth rate for kid reared on automatic machine could also be due to kid behavioral changes and the stress the kids had to go through as kids were separated from the dam and getting used to the machine. On the contrary, kids that were suckled by the dam were not subjected to any stress in relation to feeding system and environment and kids grew better than using automatic machine. The technology of Automatic suckling machine operation could be improved to reduce kid scours from cold milk in earlier days and when they are grown by installing a warming facility for reconstituted milk and electronic code for individual kids' intake. The modification will allow kids to suckle warm milk as they learn to use the machine

and reduce excess intake of milk as kid grow up. A similar automatic suckling machine is promoted for calves for similar attributes by Seipelt et al., (2003).

Time spent on kid rearing using automatic suckling machine

Unlike saving time in kid rearing and reducing milk supplies with partial suckling, automatic suckling allows for labors saving with time and increase amount of milk supplied to dairies. Time spent with the kids decreased as rearing period progressed. The first days when kids were on automatic machine, they required more time to bottle feed and train to suckle individually. Some learned faster than others which were very scared of teats and with time they could suckle due to hunger as they saw others do it. Some had the challenge to allocate teats and ended up straggling for one teat from which each could suckle based on their effort to out-compete others. The other times with the kids were for changing teats which got broken in the suckling learning process resulting in leakage of milk. Other than changing teats, more time was also spent changing beddings, cleaning the automatic suckling machine, feeding and refilling milk powder. As kids grew up most of the time was on feeding, refilling milk powder, changing beddings as need be and cleaning the machine daily. Time spent with the kids on automatic suckling machine reduced gradually as kids learned to suckle independently. The reduction in time spent in training newly introduced suckling young ones on the automatic suckling machines was also reported for calves by Jensen, (2006). The decrease in time requirement on rearing kids using automatic suckling machine offers solutions to rearing excess kids in a dairy herd when a farmer wants to engage less time on the farm and do off farm work. As such, farmers will require less and less time to manage kids reared using an automatic suckling machine. When less of the farmer's time is allocated to kid rearing, farmers will relieve their time for other income generating activities. Hence use of automatic suckling machines will relief the dairy goat farmers

off some labor that can be used more efficiently where the farmers feel fit. On the other hand, dam kid rearing relieves the farmer of time for evening milking.

Kids and stress on automatic suckling machine

Kids reared on automatic suckling machine were more stressed than dam reared kids. Kid suckling seems to explain the differences in stress for dam and machined suckled kids. High oxytocin levels were reported in restricted suckling calves compared to bucket fed calves with and without mother contacts (Lupoli et al. 2001). Oxytocin provides anti-stress effect like decreased blood pressure and lower cortisol (Uvnas-Moberg et al. 2001). In addition, research with rat and human has shown that suckling induces calming effect in newborns (Blass 1994).

Similar results were reported when comparing mature and immature male mice (Hermes et al. 2006). Hormonal imbalances during stress period in males and females reflect in behavioral differences and ability to cope with stress. Similar trends were observed for human beings.

5.4 Effects of traditional kid rearing system on farmers available milk output and kid growth rates

Available milk for farmers' use was significantly lower for twice milking and artificially suckled kids in both experiment one and two at (P=0.000). In this study, artificial feeding of kids gave 86% lower milk compared to once milking and dam suckling; and 122% compared to one teat milking and one teat suckling twice a day in experiment 1. Similar results were obtained in experiment 2, 180% milk losses with twice milking and artificial kid rearing as compared to once a day milking with kid suckling whole day and 149% compared to one teat milking and one teat suckling. Our findings agree with (Diken et al. 2008) when working with goats. Kid suckling effect appear to explain the higher level of farmers available milk due to high levels of oxytocin

which are produce with kid suckling effect (BarPeled et al. 1995; Marnet et al. 1999). Secondly, galactopoietics hormones at suckling increases milk secretion compared to two exclusive milkings per day. Thirdly, mother-young contact appears to explain the higher milk yields than none dam contact (Hernandez et al. 2007), where cows suckling gave short term increase in milk output than machine milking in cows. Long term results of suckling include enhanced mammary development, increase mammary proliferation and differentiation of mammary cells of goats (Wilde et al. 1987) and in cows (Hale et al. 2003; Hillerton et al. 1990). Fourthly, the presence of the kid influences milk let down (Hernandez et al. 2007), mother young contact gave more milk than in one contact. The presence and absence of the kid for suckling does appears to result in higher production of hormones oxytocin. Suckling induces high production of oxytocin in lactating animals (Ramos et al. 2008), and calf suckling increased oxytocin than exclusive milking for Gir cows (Negrao 2008). Fifthly, the size of gland cistern also explain the similarities in milk output and available farmers milk for dam suckling kids either with one teat milking twice a day or two teats milking once a day. Goat have larger gland cistern (80-90%) of udder milk (Peaker & Blatchford 1988).

Kid growth

This study has shown that kid growth rate was not significantly different for different suckling regimes in 2008 and 2009. Kid growth rate were similar because all kids fed on dam's milk. The results agree with (Diken et al. 2008) reported similar results for Saanen kids suckled full udder and suckling left lob of the udder. Similarly, Knight et al., (1995) reported that's lambs could be effectively reared with restricted access to ewes. In this study all goat kids fed on own dam milk by suckling or bottle feeding soon after milking. Different results are reported where goat kids are fed milk replacers because of the lower digestibility of milk replacers as compared to goat

milk (Sanz Sampelayo et al. 1990) and lack of growth promoters present in dam's milk (Baumrucker & Blum 1993). Kid growth rate found in our study are higher than those reported by Mtenga et al., (1992). The differences could be explained by differences in management of the goats.

Kid growth rate was similar also because kids fed on more less similar amounts of dam's milk. Daily milk output from one teat twice milking and once milked two teats indicate that one teat could provide enough milk comparable to 300ml to one and almost sufficient for twins. Milk output from twice milking plus 600mls fed to kid or 1200ml for twins indicate that the afternoon milk was likely to provide enough milk to the kids being suckled the dam whole day. Kid suckling does appear to produce more milk as compared to does not suckling (Hernandez et al. 2007).

5.5The tradition of milking local goats on Likoma and implications for livestock interventions

The technologies in use in a particular society will reflect the interplay between cultural values, social concerns and material needs in the communities within which they are used. But they also create meaning for the members of that particular community (Meghani 2008):31). Livestock interventions that take into account the beliefs and concerns of a particular culture in its development of the intervention can be spared from failing such as livestock when interventions flop. Where livestock interventions have been planned without taking into account cultural values, researchers or project implementers can benefit by engaging in a respectful dialogue with those who express reservations about particular technologies, because of social values or ethical values coded in them, as they are likely to bring up awareness of missing links in wasted efforts of implementing a failing project intervention.

Tea culture as celebrated in Likoma, expressing both identity and social motivation, holds the life line of milk goat rearing in the community. Studies carried out in various societies show that food, including tea, is used to maintain the ethnic identity of groups, as well as families (Brown & Mussell 1984; Gabbacia 1998; Lockwood & Lockwood 2000). Food identities are shown through food festivals in an effort to maintain historically validated identities. Food can also be made an icon of ethnic groups 'resilience in times of hunger that the identities expressed through cherished food had nothing to do with the tastiness' of the food (Diner 2003). In Likoma, tea drinking transcends festivals, it includes moaning periods, it is essential to survival in times of food shortage, it is an element in ordinary daily meals and a sign of life after food shortage. Tea is thus drunk in festivals of inter-village traditional dances, served at funeral gatherings, in daily-food meals during the day along with other dishes or alone, as the only meal in times of food shortage, and as a first essential when recovering from lack of food within a household. As community identity is so closely connected with tea drinking, goat milk rearing found an established niche in this society, because it enhances cultural values within community. Goat milk is considered to add value to tea as a more appreciated gesture in welcoming visitors, in festivals and ceremonies, and in offering tea to honorable visitors during funeral. This tea culture is passed from one generation to the other. But we know that each continuing generation also modifies the tradition according to current opportunities and challenges (Gvion 2009). On this basis we can also explain why those who can afford it prefer to use powdered milk instead of goat milk.

For poorer people goat milk rearing in Likoma offers protection from uncertain fishing incomes and fits well with the daily work schedules. During periods when fish catches drastically drop, or fail because of bad weather at the lake, goats become essential as livestock to be sold for household income to buy food. In addition, when dry fish sales are not profitable on the mainland and business men and women lose capital, goats offer alternative stand- by capital.

Within the resource context of Likoma, livestock species that do not compete with man for feed are ideal because of lack of resources. Importing feed requires a great income reserve, and in times of dwindling

fish catches in Lake Malawi, relying only on fish income would be stressful for the household. Goat rearing fits well since goats feed of grass and bushes in the rainy season and survive mostly of tree leave supplement in the dry season. Other than contributing to survival skills of Likoma community in times of food shortage, the goat milk plays a key role in festivals and ceremonies that link goat rearing to core cultural values. As such, households belonging to different extended families ensure that they own goats. Family leaders ensure that each one has a goat to increase the resource base in times of need. A mature female goat is loaned to kinship relations and marriage relations and also to friends. The perception of the community of goat rearing as a resource bank allows for self-propagation of goat rearing, which also ensures provision of goat milk.

Social cohesion emanating from promotion of milk goat rearing by farmers themselves has a positive feedback. There is much empirical evidence that farmer learn from other farmers cultivating same crop (Foster & Rosenzweig 1995; Munshi 2004). As goat keepers on Likoma loan each other's goats, goat rearing becomes a social value as one starts goat rearing through establishing informal lender-borrower linkages with fellow goat keepers. And milk goat rearing is not only for a special group of people, membership is open. Since goat rearing is for everybody, goat rearing has become important in social capital building for sustainable rural livelihoods. The community perceives goat rearing as a resource each one can tap into and better their own life.

Goat loans through the *kuweta* system within the community provide a platform for exchange of information and farmer to farmer learning, and a basis to ensure success for new adopters. Households borrowing goats on loan benefit from hands-on and shared experiences from the goat lender. Informal and close contacts with goat owners in the community offers better knowledge transfer and sharing from lead farmers to enable success of goat milk rearing. This finding is in agreement with technology adoption studies of farmers which indicate that farmers decisions to adopt correlate with both choice of their network of family and friends and also members of the same church (Bandiera & Russel 2006):871).

Goat farmers lend out goat to relations and trust-worthy friends or community members. These loans are based on trust and trust is glue in social networks (Gambetta 1988). The high numbers of lending to kinship reflect that goat farmers trusted most those they were affiliated to.

As the social status changed, many preferred powdered milk. But they maintain Likoma tea culture! With more economic resources they have more options for obtaining milk for tea, and at the same time prefer fast growth rate for kids.

6. CONCLUSION AND FUTURE PERSPECTIVES

The study has shown that dam kid rearing is profitable for better quality milk delivery to dairies and labor saving on kid rearing which can offer extra income from sales of goat kids. Adopting day and night grazing management tool for dam kid rearing on mountain pasture would optimize utilization of mountain pasture, allow for better kid growth rates and offers high milk yield. When farmers have lactating goats in winter, automatic suckling machine offers alternative rearing method of replacement stock to allow for high milk supplies to dairies at this period when goat milk price is high. In support of dairy improvement programs in the tropics, this study has shown that traditional suckling regimes of once a day milking offers high amounts of farmer's available milk and where fresh supplies of milk are required for household use one teat milking and one teat suckling is beneficial to the household. The study also highlights the significance of cultural, social and environmental context of dairy goat interventions for sustainability and utilization of livestock interventions.

Future perspectives of similar studies would need to focus on how goat meat kids can be promoted within Norwegian culture; and social and environment to establish a market for goat

kids reared on mountain as that would sustain the cultural landscapes which are a cultural heritage. Along with product acceptability and mountain pasture utilization research; there is a need of continued efforts to employ management practices for increase of good quality milk supplies in winter by ensuring good body condition at kidding to reduce off-flavors. Where productivity of dairy goats are limited by dry season feed shortage, research on use of multipurpose fodder trees, along with utilization of conserved natural forage within the feed resource base; preferential or strategic supplementation to different classes of goats would be a key to improving productivity.

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Manuscripts I –V

Paper I

Partial suckling and late kidding as a management tool to reduce kid rearing cost and improve distribution of goat milk to Norwegian dairies

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Abstract

Sixty –six does in year 1 and 69 does in year 2, Norwegian goats were bred for kidding in April to June. Does were randomly allocated to dam grazing groups of zero kid, one kid and two kids within 2 weeks after birth based on age, kidding date, litter size and sex of the offspring. The dams grazed with their kids on mountain natural pasture until weaning at end of mountain period. Dam reared kids stayed with the dam from 0900-1500hrs and were separated at night until after morning milking. Dams with zero kids were milked twice daily and those with 1 and two kids once. Weekly milk yields, kid weights, monthly dam weights and initial and end weight of grazing periods were recorded. Weekly milk samples were analyzed for milk composition and somatic cell counts (SCC). Feeding behavior was observed every 30 sec for half an hour for 12 animals in year 1 and 20 in year 2 for does suckling zero and two kids.

None suckling goats gave more milk than suckling does in year 1(2.17kg/day versus 1.24 and 126kg/day) and two (1.98kg/day vs 1.27 and 1.23kg/day). Energy collected milk was 50% higher for non-suckling does than suckling does. Increase in number of suckling kids decreased milk butter fat% but increased lactose %. Milk protein was not significant for number of kids suckled. SCC was not significant for number of kids suckled but increased with parity and as lactation progressed. Kid growth rates were similar for one and two kids reared by the dam in year two (162g/day vs158g/day) and higher for single kids in year one (172g/day vs 162g/day). Foraging behavior was similar for dams rearing different number of kids. Therefore, dam kid rearing is profitable for better quality milk delivery to dairies and labor saving on kid rearing which can offer extra income from sales of goat kids.

Key words: kids, suckling, grazing, Norwegian, mountain, behavior

Introduction

In Norway, milk is the major product of the goat industry and most of the milk is processed to cheese in central dairies. Farms are either located in coastal or inland mountainous areas. While grazing is available in abundance and goats play an increasing important role to prevent bush-encroachment, cultivated grassland for silage-making is a limiting factor on many farms. Kidding normally takes place in February and the goats are barn-fed until start of grazing in May or June. The grazing on the natural range pastures ends in September or October. The goats are

then milked for a period of 1-3 months and dried off 2-3 months before parturition. The result of this system is peak deliveries of milk from April to September and shortage during mid winter. A new brand of cheese, ”Snøfrisk”(i.e. snow-fresh), has been successfully marketed both locally and abroad. ”Snøfrisk” is a white spreadable cheese, which can be stored for only three months. Hence, producing this cheese requires even supplies of high quality milk through-out the year.

The Norwegian dairy goat population amounts to 45,000does. Today, only kids for replacement are saved and most of the other approximately 75,000 kids are disposed of shortly after birth or slaughtered for meat after 3-5weeks of age. Killing of surplus kids has been criticized by animal rights advocates, and goat farmers dislike the practice themselves. Although meat from young goat kids is popular in many countries, it has proven difficult for Norwegian producers to establish a profitable market. In addition meat production on young kids does not allow for utilization of low-cost roughages and pastures available on the farm.

Livestock farming systems, in Europe play a central role in the management and conservation of large high-nature-value farmland located in favorable area like mountainous regions (EEA 2004). Despite Norway not being part of the latter report, 91% of the land in Norway is mountainous (NORDREGIO 2004). In addition, cultivated land in costal and mountainous regions of Norway is not suitable for grain production due to climate conditions and unsuitable topography. Therefore, grazing goats on the mountains becomes a relevant management system. In Norway, mountain grazing of goats has also been used to prevent encroachment of open diversity cultural landscapes and governmental support is provided for such management-system (Asheim & Eik 1998; Asheim & Eik 1999; Clemetsen & Eik 2004)

The objective for this study was therefore to evaluate effect of single and twin dam kid rearing during mountain and autumn grazing on milk yield, composition and quality in goats with spring kidding to allow for continuous milk supply through-out the year and reduce kid rearing cost through dam kid rearing on mountain pasture.

Materials and methods

Study site

The study was undertaken for two consecutive years and involved use of cultivated lowland pasture located in the University farm with altitude of 150 m above sea level and latitude of 59°40' North and alpine (mountain) pasture located 350 km north of Oslo with altitude 900-1000 m above sea level and latitude of 62°18' North. The lowland pasture consisted of timothy and Trifolium species while the major plant species in the mountain pasture were sedges in marsh areas, grasses and willow thickets (salix) and *Betula nana* in the drier areas.

Animals and management

A total of 135 Norwegian dairy goats (66 and 69 in year 1 and 2, respectively) were used in the two year experiment. The goats were selected on the basis of age, date of kidding, litter size and sex of offspring's. The kidding season ranged from end of April to mid June. Animals were grazed on lowland pasture during the spring period (May/June, period A), mountain pasture during the summer (July/August, period B) and back to lowland pasture in autumn (September, period C). Does were allowed to graze together with their kids during spring period. At the

beginning of mountain period does were divided into three groups based on number of suckling kids (no suckling kid, one suckling kid or two suckling kids). Kids stayed with their dams during day time (0900-1500) and were kept indoors separately during night hours. Kids were not supplemented with concentrate. In the first year, dam concentrate supplementation for all dams in period A was at 0.4kg/day. At the beginning of period B (Mid July to August), dams on day grazing only continued concentrate supplement of 0.4kg/day while day and night grazing dam were fed 0.1kg/day. The lest of period B through to period C, concentrate levels for day and night grazing was increases to 0.4kg/day while day grazing only to 0.7kg/day. In year two all dams were on similar concentrate levels but varied with period. In period A, all dams were fed 0.4kg/day. In period B, concentrate reduced to 0.2kg/day and in period C it was up to 0.4kg/day. Day grazing goats were grazing for seven hours while day and night grazing flock grazed for 18 hours. All kids were weaned after mountain grazing period.

Milk recording and sample collection

Goats without kids were milked twice while does rearing kids were milked once daily (Year 1 and 2) throughout until weaning at 6-8weeks. Milk yield was recorded weekly on two subsequent days while milk samples were collected once weekly, from morning and afternoon milking, for analysis of chemical composition (fat, protein and lactose) and cell counts using Fossomatic method.

Milk samples were preserved with 2-bromo-2-nitropropane-1,3-diol and analysed for fat, protein and lactose using Combifoss instrument (Milkoscan 225 A/B and Fossomatic 250, Fosso-

Electric, DK 3400 Hillerød, Denmark). Milk samples were also analyzed by professional tasters where milk was given scores of 1 for milk tart and 5 for good milk taste.

Body weight measurements

Body weight changes of does were measured four weeks before kidding, two days post kidding and every four weeks thereafter throughout the experimental period. Body weights of kids were taken shortly after birth and every four weeks thereafter till the end of the experiment.

Foraging behaviour

During the mountain grazing period 12 does in year one and 20 does in year two with single suckling kids were used to study foraging/grazing behaviour. The mountain period was divided into three sub-periods with three days in each. The observation was made on individual doe every 30 seconds for half an hour per day per doe. The method has been described by Autumn (1974) as a 'Focal method' with 'Instantaneous sampling'. The various activities recorded included browsing, grazing, walking, standing, lying, ruminating.

Statistical analysis

Milk yield, milk composition, somatic cell counts, body weight measurements, foraging behavior data were analyzed using Mixed procedures of SAS (SAS 2003). Energy corrected milk(kg) was calculated as using milk yield, milk fat, milk protein and lactose as (0.01 x day yield of milk (kg) + 12.2 fat(kg) + 7.7 x protein(kg) + 5.3 lactose(kg).

The model for milk yield, milk components and somatic cell counts analysis was:

$Y_{ijkl} = \mu + G_i + N_j + P_k + a_l + (GxN)_{ij} + (NxP)_{jk} + (GxNxP)_{ijk} + e_{ijkl}$

Where

Y_{ijkl} = Milk yield/Milk components/Somatic cell count

μ = Overall mean

G_i =Grazing time of the year at two levels (I = Mountain grazing, Autumn grazing)

N_j =Number of kids suckled by dam at three levels (j = 0 kid, 1 kid, 2 kids)

P_k =Grazing period at three levels (k= Mountain period 1, 11&13 July; Mountain period 2, 8 &10 August; Mountain period 3, 28&30 August)

a_l = l^{th} effect of individual goats (l=1….12/20)

$(Gx\ N)_{ij}$= Interaction of two effects (grazing time of the year and number of kids suckled)

$(NxP)_{jk}$= Interaction of two effects (number of kids suckled and dam and grazing period)

$(GxNxP)_{ijk}$= Interaction of three effects (grazing time of the year, number of kids suckled and grazing period)

e_{ijkl} = random effect of residual

The model for goat behavior analysis

$Y_{ijkl} = \mu + G_i + P_j + T_k + a_l + e_{ijkl}$

Where

Y_{ijkl} =Behavior activity recorded

μ = Overall mean of percent activity for whole observation period

G_i = Grazing system for goats at two levels (i = Day grazing, Day and night grazing)

P_j = Time of the year when goats were observed at three levels (1= Mountain period 1, 11&13 July); 2= mountain period 2, 8 &10 August; 3= Mountain period 3, 28&30 August)

T_k = Period of the day when observation was made at two levels (1= Day time (morning and afternoon); 2= Night time observation)

a_l = l^{th} effect of individual goats ($_{l=1....12}$)

e_{ijkl} = random effect of residual

Results

Effect of number of suckling kids on kid growth rate, milk yield, composition and quality for mountain and autumn grazing

Non suckling goats gave more saleable milk than suckling during mountain grazing but no significant differences after weaning during autumn grazing of year 2. Increase in number of suckling kids decreased fat percent of dam's milk but had no effect on protein. In addition, increase in number of suckling kids increased somatic cell counts. Somatic cell counts also increased with parity and progression of lactation (Table 1).

Table 1

Effect of number of suckling kids (0, 1, 2) on milk yield, composition and quality during mountain and autumn grazing periods

Grazing period	Mountain			Autumn				P-value				
Number of kids	0	1	2	0	1	2	SEM	Grazing period	Number of kids 0 vs. 1	1 vs. 2	0 vs. 2	Interaction
Experiment 1:												
Milk yield, kg/day	2.17 ^{c}	1.24 ^{a}	1.26 ^{a}	1.85 ^{b}	1.87 ^{b}	1.87 ^{b}	0.075	<0.0001	<0.0001	ns	<0.0001	<0.0001
Milk yield, kg ECM/day	1.93^{a}	0.985^{b}	0.980^{b}	1.66^{c}	1.66^{c}	1.76^{c}	0.065	<0.0001	ns	<.0001	<0.0001	<0.0001
Fat (%)	3.58^{a}	2.68^{b}	2.55^{b}	3.72^{c}	3.65^{c}	3.93^{c}	0.136	<0.0001	<0.0001	<.0001	<0.0001	<0.0001
Protein (%)	2.82^{a}	2.91^{a}	2.85^{a}	2.73^{b}	2.74^{b}	2.86^{b}	0.053	0.0053	0.0105	ns	ns	0.067
Lactose (%)	4.44^{a}	4.41^{a}	4.46^{a}	4.24^{b}	4.33^{b}	4.42^{b}	0.051	<0.0001	0.0164	0.0622	0.0031	0.087
Dry matter (%)	10.84^{a}	10.00^{b}	9.87^{b}	10.68^{c}	10.72^{c}	11.21^{d}	0.172	<0.0001	ns	0.0003	0.0011	<0.0001
Somatic cell count, x1000	96^{a}	112^{a}	173^{a}	1363^{b}	798^{c}	908^{c}	64.3	<0.0001	<0.0001	<.0001	<0.0001	<0.0001
Kid growth rate g/day	-	173^{a}	162^{b}	-	-	-	0.004	-	-	0.0826	-	-
Experiment 2:												
Milk yield, kg/day	1.98^{a}	1.27^{b}	1.23^{b}	1.63^{c}	1.33^{d}	1.33^{d}	0.073	0.016	<0.0001	ns	0.0002	<0.0001
Milk yield, kg ECM/day	1.72^{a}	0.947^{b}	0.938^{b}	1.12^{c}	0.862^{d}	0.864^{d}	0.073	<0.0001	0.073	ns	ns	<0.0001
Fat (%)	3.10^{a}	2.38^{b}	2.12^{c}	3.49^{d}	2.81^{e}	2.99^{e}	0.113	<0.0001	<0.0001	<.0001	<0.0001	0.0313
Protein (%)	3.00^{a}	2.90^{a}	2.98^{a}	2.85^{b}	2.69^{b}	2.79^{b}	0.141	ns	ns	ns	ns	ns
Lactose (%)	4.26^{a}	4.15^{a}	4.02^{b}	3.24^{c}	4.11^{c}	4.11^{c}	0.065	ns	ns	ns	0.0340	ns
Dry matter (%)	10.35^{a}	10.36^{a}	10.47^{a}	10.56^{b}	12.48^{c}	13.54^{c}	0.703	<0.0001	ns	0.0935	ns	0.0104
Somatic cell count, x1000	1247^{b}	2130^{a}	1047^{b}	1593^{c}	2400^{d}	3200^{d}	378	0.0008	ns	0.0656	ns	0.0288
Kid growth rate g/day	-	162	158	-	-	-	0.005	-	-	0.2614	-	-

SEM: standard error of mean; ns: non significance; letters in line indicate pairwise differences (5%)

Different superscript letters within a row denote significant differences.

Milk production trend for different numbers of kids suckled during mountain and autumn grazing

Figure 1 presents milk yield curve with different numbers of kids suckled. Suckling kids produce less marketable milk compared to non suckling but provide comparable milk after weaning kids.

Milk production trend for weeks of the year

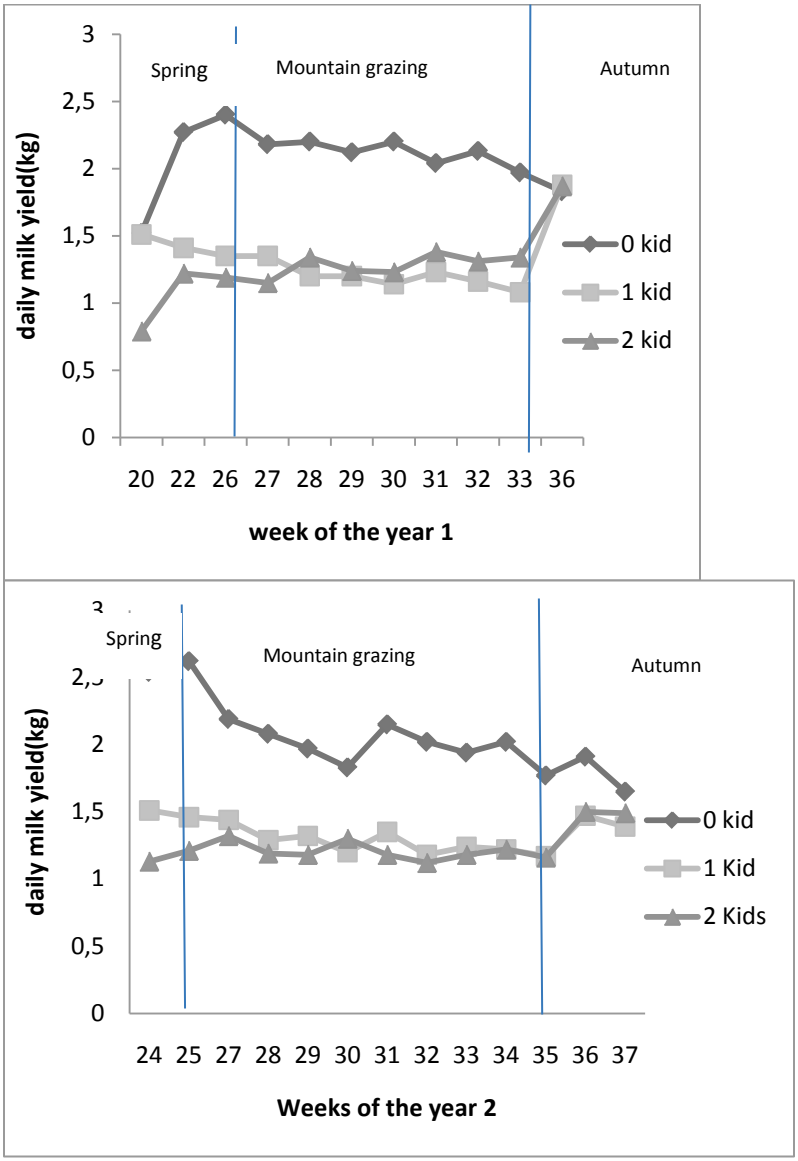

Figure 1: Daily milk yield trend per week of the year for different numbers of kids suckled (lsmean)

Kid and dam live weight changes with different numbers of kids reared by the dam

Figure 2 shows the growth trend of kids on spring, mountain and autumn grazing. Despite the lower weight of kids reared as twin by the dam, after weaning, both single and twin kids strive after weaning.

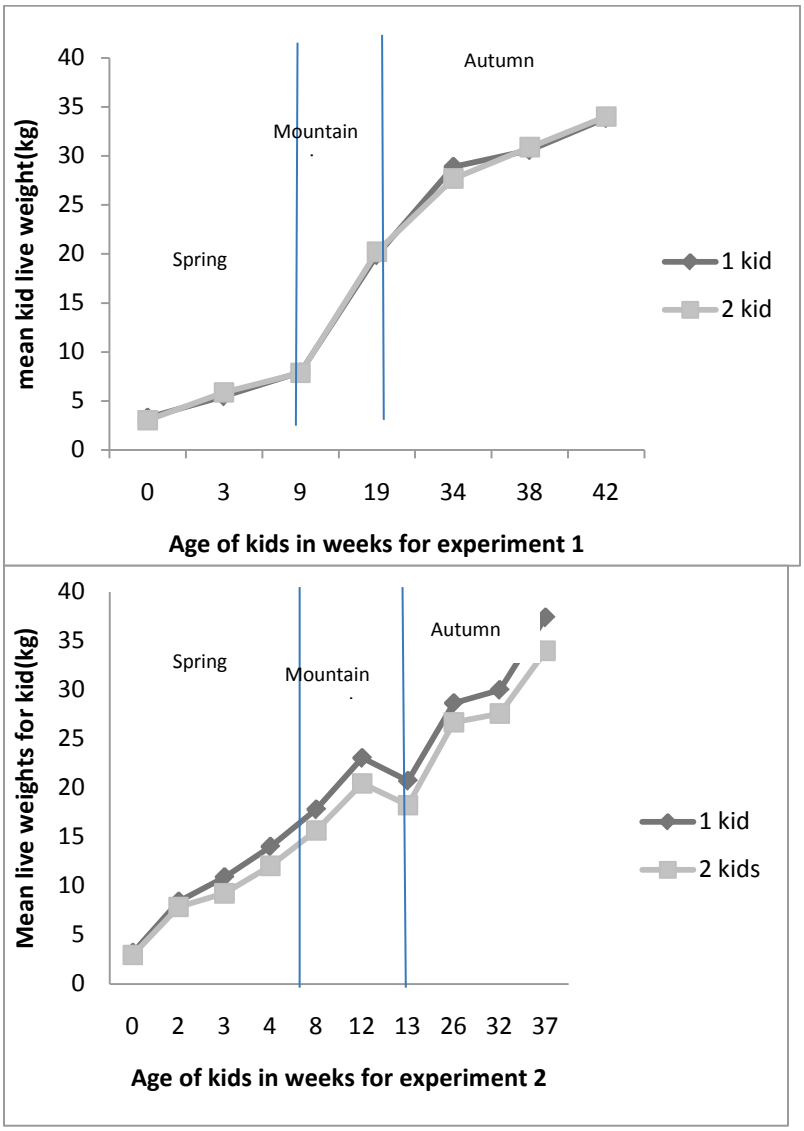

Figure 2: Mean kid live weight trends for 1 or 2 kids suckled by a dam during spring, mountain and autumn grazing periods.

Lactating does lost weight during mountain grazing and gained weight in autumn after weaning kids (Table2).

Table 2

Changes in dam live weights for goats suckling 0, 1 and 2 kids during mountain and autumn grazing periods

Dam live weight (kg)	Does with 0 kid	Does with 1 kid	Does with 2 kids	SEM	P-values
Experiment 1					
Live weight(kg) 2-days postpartum	46.04	45.87	50.91	1.8887	0.1610
Live weight(kg) at end of Spring grazing, 35-days postpartum	36.76	37.65	40.42	1.4459	0.2649
Live weight(kg) Mountain grazing, 105 day postpartum	40.43	40.62	43.43	1.1135	0.1810
Live weight(kg) end of Autumn grazing 127days postpartum	39.23	39.93	42.75	1.2347	0.1788
Dam Spring weight changes(g/day)	-312	-233	-214	0.0487	0.2956
Dam Mountain weight changes(g/day)	56	50	50	0.0142	0.9329
Dam autumn weight changes(g/day)	22	12	22	0.0197	0.8943
Experiment 2					
Live weight(kg) 2-days postpartum	50.74[a]	50.48[a]	56.03[b]	2.0425	0.1367
Live weight(kg) at end of Spring grazing, 35-days postpartum	40.61[a]	40.82[a]	45.39[b]	1.0536	0.0051
Live weight(kg) Mountain grazing, 105-day postpartum	40.41[a]	40.14[a]	43.65[b]	0.6947	0.0012
Live weight(kg) end of Autumn grazing 199-days postpartum	42.35	42.38	45.14	1.0105	0.1146
Dam Spring weight changes(g/day)	25	27	23	0.0256	0.9957
Dam Mountain weight changes(g/day)	-17	-3	-15	0.0072	0.3323
Dam autumn weight changes(g/day)	-2	-12	-22	0.0123	0.5432

SEM =standard error of mean; ns= non significance, Different superscript letters within a row denote significant differences.

Feed selection behavior of dams suckling zero or two kids during mountain grazing period

There were no differences in feed selection behavior of dams suckling zero or two kids during mountain grazing (Table3).

Table 3

Least square means of percentage variation in forage selection by goat grazing with different numbers of kids

Selected forages	N	Dams with 0 kid	Dams with 2 kids	SEM	P-Value	Significance
Experiment 2						
Grasses	20	38.14	35.37	4.0639	0.6264	ns
Sedges	20	6.66	4.94	2.0144	0.5433	ns
Grass-like	20	44.81	40.31	4.3925	0.4662	ns
Forbs	20	5.09	3.76	1.1542	0.4094	ns
Herbage	20	49.90	44.07	4.4008	0.3457	ns
Leaves	20	48.78	55.18	4.3682	0.2977	ns
Leaves and Bark	20	48.82	55.24	4.3626	0.2973	ns
Juniper	20	0.92	0.45	0.3287	0.3182	ns
Fungi	20	0.04	0.21	0.1268	0.3386	ns
Other plants	20	0.70	0.94	0.3183	0.5878	ns
Other sum	20	1.65	1.60	0.4830	0.9426	ns

SEM =standard error of mean; ns= non significance

Different superscript letters within a row denote significant differences.

Table 4 shows that except for suckling, behavior of goats suckling and not suckling was similar.

Table 4

Least square means of percentage variation in goat behavior during mountain grazing by goats grazing with different numbers of kids

Goat behavior	N	Dams with 0 kid	Dams with 2 kids	SEM	P-Value	Significance
Experiment 2						
Feeding	20	52.2505	51.4958	3.1788	0.8646	ns
Grazing	20	23.1979	19.4624	2.7875	0.3367	ns
Browsing	20	28.9047	31.9362	2.7847	0.4348	ns
Non-feeding activity	20	47.4874	48.4831	3.1652	0.8212	ns
Walking	20	30.6852	28.1438	2.6702	0.4946	ns
Standing	20	2.2090	1.4659	0.6298	0.3974	ns
Resting	20	14.2681	18.1894	3.9792	0.4795	ns
Suckling	20	0	0.3288	0.1164	0.0379	s
Other activities	20	0.3360	0.3552	0.1196	0.9084	ns
Sos other activities	20	2.5342	2.1499	0.6807	0.6851	ns

SEM =standard error of mean; ns= non significance

Different superscript letters within a row denote significant differences.

Discussion

Milk yields

Number of suckling kids per dam significantly affected the milk yields for sale (P=0.0001) as shown in Table 1 and Fig 1. We observed higher milk yield for none suckling does in experiment

one and two. In experiment one, dams with zero kid gave 43% more milk for sale than dams suckling one kid and 42% more milk than dam suckling two kids. In experiment two, dams suckling zero kids gave 36% more milk than dams suckling one kid and 39% more milk than dams suckling two kids. Our results differ from Delgado-Pertnez et al.(2009), where higher milk yields were observed for dams in natural suckling group. However, our results are not comparable because our milk yield did not include what kids consumed. Kids were suckling after milking and separated from dam at night. Rearing system allowed for milking only milk that was secreted over night, taking advantage of the cisternal gland milk storage between milkings (Bruckmaier et al. 1994; Peris et al. 1996). The alveolar milk ejection which is oxytocin mediated benefitted the suckling kids who obtained available milk. During mountain grazing when all does were being milked, all does lost weight unlike in autumn. Weight losses on the mountain could firstly be due to differences in management of the goats because maintenance requirements could be higher as opposed to farm rearing when goats do not move a lot. Secondly, energy requirement of lactation before peak milk yield are higher as noted from use of body reserves to maintain lactation. Losses in weight during early lactation were also observed for mature and primiparous animals (Eslamizad et al. 2010) and body weight changes of matures could yield more energy to maintain lactation than growing animals. Post weaning milk yield were similar in experiment one and were 20% higher for none suckling dam than suckling dam in experiment two. Kid rearing system had no effect on subsequent milk yields after weaning in the first lactation but the effect was prominent in second lactation. Similar results were observed when working with primiparous and multi parlous goats (Wall & McFadden 2008). Myoepethelial cell differentiation and apoptosis variations between primiparous and multiparous goats also explain the differences. On the contrary, Bar-peeled (1995) reported enhanced mammary development through suckling and milking because of higher proliferation and

differentiation of mammary cells. Overall, milk yield decreased as lactation progressed because early lactation has more secretory cells in mammary gland and these cells may have greater potential to respond to stimulus at milking than cells in late lactation (Wall & McFadden 2008). Decline in milk yield after peak appears to be explained by the decline in mammary cells and abrasion of cell during milking (Boutinaud et al. 2004; Li et al. 1999; Stefanon et al. 2002).

Energy collected milk during mountain grazing that was delivered to the dairy was 50% higher for dams with zero kid than dams with one kid and 59% higher than dam suckling two kids. The trend changed for post weaning energy collected milk yields, with 6% increase in energy collected milk for dam that suckled two kids than zero and one kid suckling does. On the other hand, energy collected milk in experiment two were 45% higher in none suckling dams than suckling dams of one or two kids during mountain period. After weaning, energy collected milk was 23% higher in none suckling dams than suckling dams.

Late kidding and kid suckling while grazing mountain pasture delays meeting quota allocation for milk production, allows for extra income from annual quota by supplying more milk later when the price is higher than summer, even annual distribution on milk supplies to dairies and meat production from goat kids slaughtered after mountain grazing. In Norway, goat kidding occurs in January and February and therefore dairies have peak milk quota supplies in summer (June). Milk supplies to dairies reduce becomes uneven in late fall (August) to early winter (October). Late kidding and kid suckling during mountain grazing as demonstrated in our study, delays meeting milk quota and allow for supply in periods of shortage. Moreover, Norwegian Dairy (Tine), pays farmers

extra for milk supplies in early winter (Grindaker personal communication 2011), and therefore late kidding and kid suckling may increase farmers income from milk and meat of goat kids.

Other than better income from milk and even distribution of milk supply, late kidding and kid suckling will allow for meat production from goat kids slaughtered after mountain grazing. Goat kids can also be used in bush control (Baraza et al. 2009) and production of cashmere-fiber (Asheim & Eik 1998).

Milk Composition and quality

Number of suckling kids for the dam significantly (P=0.0001) affected amount of fat g/kg of milk. Milk fat appears to decrease with increase in numbers of kid that the dam suckled. We found that dams not suckling gave milk with 25% higher fat in g/kg than dams suckling 1 kid and 28% more fat than dam suckling two kids in experiment one. Similarly, in experiment two, milk fat was 23% higher in none suckling dam than dam suckling one kid and 28% higher than dams suckling two kids. Post weaning milk fat was higher than during suckling period. Milk fat was 5% higher in dam suckling zero kids than dams suckling one or two kids in experiment one. On the other hand, in experiment two, milk fat during post weaning period was 19% higher in none suckling dam than dams suckling one kid and 14% higher than dams suckling two kids.

Suckling is known to trigger a neuroendocrine reflex and a hormone oxytocin which is important in milk ejection and secretion. Milk ejection reflex appears to have a marginal effect in ruminants because they have cisternal cavities, such that udder denervation does not abolish lactation. Small ruminants have a proportionately larger cistern of 40-80% of total volume (Bruckmaier et al. 1994) The larger cistern allows for storage of milk in between milkings and influence milk removal at milking. Studies on milk ejection reflex by dairy ewes and goats indicate bimodal flow curves with

first peak due to cisternal milk discharge and the second peak from alveolar milk ejection by myoepithelial cells contraction (Labussiere & Ricordeau 1970). Alveolar milk ejection requires oxytocin as observed by Labussiere (1969) because dairy ewes with denervation of udder do not undergo bimodal milk flow. However, in goats, oxytocin release is highly variable within and between animals and can be unimodal or multimodal during one milking (Marnet & Negrao 2000). Unlike in dairy cows where oxytocin release correlate with milk flow emission pattern, in goats, either very high milk yields, strong milk flow rate or increase in intramammary pressure have no corresponding increase in plasma oxytocin concentration above baseline levels during milking (Hernandez et al. 2007). In addition, despite the lower dependency of milk removal on oxytocin, oxytocin mediated milk ejection is important for secretion of milk from alveolar. Although small ruminants benefit from cisternal milk storage, almost 75% of milk fat secreted remains in alveolar fraction and is obtained with oxytocin mediated injection (Labussiere 1988).

Dam kid rearing significantly reduced milk fat percentage (P=0.0001). Milk fat decreased with increase in number of kids reared by the dam. Dam weights indicate a decline in weight for all does on the mountain with more losses with increase in number of kid reared emphasizing the increase in nutrient requirements or suckling does though it was not significant. Along with the higher losses in weight for suckling dams, is the decrease in milk fat. The trend denoted a link between fat synthesis and maintenance energy requirements of suckling dams. As a consequence as less energy, less fat was synthesized. Unlike, several authors have reported a correlation of decrease in milk and increase in milk constituents like fat; which is explained by the effect of concentration- dilution induced by variation in milk produced (Morand-Fehr et al. 2007; Peris et al. 1997). In our study kids suckled after machine milking, therefore, suckling does appear to secrete alveolar milking when

suckling the kids. Kid suckling allowed for release of oxytocin- mediated milk ejection that allowed the kids to drain alveolar milk, which has 75% of fat) than gland cistern milk that was milked by machine(Labussiere 1988). In addition, none suckling dams did not withhold any milk at milking because they did not have maternal rearing extinct observed in suckling dams. Therefore, we observed high milk fat in none suckling dams than suckling dams.

On the other hand, milk protein was not significantly different for various numbers of suckling kids and for suckling and post weaning period in both experiment one and two. Lactose was higher during mountain grazing in experiment one (44 vs 43g/kg) and similarly in experiment two (41 vs 38 g/kg). Milk lactose was higher for dams suckling two kids during suckling period in experiment one and not significant for number of kids suckled in experiment two. After weaning, milk lactose was higher for suckling dams than none suckling in experiment one and two though not significant in experiment two. Milk total solids were higher (P=0.0001) in post weaning period than during suckling period; and increased with increase in number s of suckling kids. Note as lactation progressed there is a tendency to increase in number of total solids for dairy animals.

In addition, experiment one showed that somatic cell counts tended to increase with increase in number of suckling kids though not significant. On the other hand, both experiments showed that somatic cell counts increased as lactation progresses. Somatic cell counts were significantly higher (P=0.0001) in autumn in experiment one and two. We observed 80% increase in somatic cell counts as the goats moved from mountain period to autumn in experiment two and 806% increase in experiment one. The levels of somatic cell counts observed in our study are higher than 100,000

except milk for none suckling dams in experiment one. Somatic cell counts are used to monitor udder health and milk quality in dairy cattle industry (Haenlein 1999). A maximum level of somatic cell counts in sheep and goats is lower than 1,000,000 SCC/ml (Haenlein & Hinckeley 1995) because of presence of cytoplasmic particles resulting from apocrine milk secretion in goat udders, while for cow udders is merocrine (Atherton 1992; Maisi 1990). European union somatic cell count limits applicable to production of sheep and goat in directive 94/71 enforced on 1/12/99 is lower than 1,500,000 SCC/ml for products based on thermically treated milk; and lower than 500,000SCC/ml for non-thermatically treated milk(Pirisi et al. 2000). The maximum levels for somatic cell counts in goats is higher than of cows which is lower than 400,000SCC/ml for European union because healthy goat udders have high somatic cell counts as observed from patho-histological sections of goat udders in the absence of mastitis condition(Haenlein, 1999). Norway uses the same lower limits for somatic cell counts as Europe. Norwegian Dairies(TINE 2011), have four classes of goat milk according to somatic cell count as Elite, below 1,500,000; 1 klasse between 1,501,000 and 1,750,000; 2 klasse between 1,750,000-2,000,000; and 3 Klasse for counts above 2,000,000. The Somatic cell counts observed in this study were within the range of good quality in the first parity but increased much more in the second parity. In addition, as lactation progressed, somatic cell counts increased. Somatic cell counts increased firstly, because of parity (Haenlein 2002; Moroni et al. 2005; Paape et al. 2007) as noted from first to second experiment. Secondly, somatic cell counts are known to increase as lactation progresses (Boyazoglu & Morand-Fehr 2001), (Haenlein 2002; Moroni et al. 2005; Paape et al. 2007) as noted in differences between mountain and autumn grazing. Increase in somatic cell counts was also observed for cows (Guo et al. 2010; Hagnestam-Nielsen et al. 2009). Thirdly, the increase in somatic cell counts observed in autumn relate to estrus cycle of the goats, in that at the end of summer, goats also coming on heat in

the northern hemisphere, estrus appears to elevate somatic cell counts (Haenlein 1999; McDougall & Voermans 2002; Moroni et al. 2007).

Kid suckling allows for a reduction in supply of milk with off-flavors to dairies and increase amount of milk supplied after weaning when it is easy to maintain a positive energy balance, and therefore reduced off-flavor. Goats in positive energy balance, with body fats reserves, produce high quality milk as noted from a negative correlation between body weight and milk free fatty acids (Donnem et al. 2011). In our study, goats kidded in May, which is late kidding in Norway where goat kidding is mostly in February. Late kidding allowed for high utilization of mountain pasture, optimal utilization of concentrate and also reduced off-flavor in milk. In early lactation goats are in negative energy balance and fat stored in adipose tissues is mobilized to maintain milk production (Dunshea et al. 1990). May kidding allowed the goats to be put on pasture when they were in good body condition, because goats of low body mass index have high amounts of milk free fatty acids in early lactation (Donnem et al. 2011). Increase in milk free fatty acid is positively correlated to off-flavor (Collins et al. 2003), and studies have shown that goats of poor body tends to give milk of strong tart (Donnem et al. 2011). This is because good body condition reduces the stress of peak milk yield production and suckling which result in immobilization of body reserves (Eknaes et al. 2006). With late kidding, peak milk yield, suckling periods and mountain pasture grazing coincide. Therefore, dam kid rearing allow for use of milk of off-flavor, when goats are in negative energy balance. Off-flavor and fatty acid tests from single sampling were not different for different numbers of kids suckled probably because goats were in similar body condition when put on pasture. On the contrary, traditional kidding of goats in February allows for supply of milk with off-favor to dairies and reduces use of mountain pastures. With February kidding goats are put on pasture when in poor body

condition and farmer resort to use of concentrate. Use of high concentrate when goats are on pasture result in substitution effect as goats feed less of pasture (Eik et al. 1991),

Daily kid growth rates and dam weight changes

Kid live weight gains were similar for one kid and two kid dam sucking though slightly higher for single kids. The trend was observed during mountain, spring and end of autumn (Fig 2 and Table2) Therefore, our study has shown that goat kids can be reared by the dam and attain similar end weights as single reared kids. Average mountain live weight gains for one kid rearing was 167 and two kid dam rearing was 162g per day. Though the twin grew slowly during suckling period, post weaning weights indicate that twin kids could catch up with the single reared kids. Natural rearing which was used in this study provided dam milk to all kids. Unlike where kids are reared on milk replacers which are known to have lower digestibility compared to dam milk (Sanz Sampelayo et al. 1990) and lack growth promoters (Baumrucker & Blum 1993). Natural kid rearing gave higher average daily gains compared to artificial rearing (Arguello et al. 2004; Piasentier et al. 2000) . Kids suckled milk available in the udder but possibly in differently quantities hence the differences in weight gain though not significant. Natural rearing kids gave comparable results to artificial reared kids fed on milk replacers when kids ingested feeds of similar metabolizable energy (Delgado-Pertinez et al. 2009).

Dams were with zero, one and two kids were all losing weight till lactation week 12 when kids were weaned (Table2). The weight changes during spring, mountain and autumn grazing were not significantly different for number of kids reared by the dam (Table2). Weight lose observed during mountain grazing could be explained by lactation stage of does, higher energy requirement for

walking long distance (Eknaes et al. 1999) and grazing on natural pastures of variable nutrient content. Loss of body weight in early lactation is a well known phenomenon in dairy. Lactating animal require more energy in early lactation until peak yield and can be in negative energy balance. When lactating animals are in negative energy balance, energy for milk production is mobilized from body reserves, hence the tendency to lose weight. In our experiment dams lost 11% of live body weight from kidding to weaning. Lose of body weight in lactating does has been linked to off-flavors in the milk (Eknaes et al. 2006), when a goat loses more than 30-40% of adipose tissue. Kid rearing system by the dam allows for use of poor quality milk in kid rearing till weaning. The increase in dam weights to normal after weaning allows for milk production which is acceptable by being of less taint and good quality for dairy products.

Feeding behavior of dams (Table 3 and 4), on the mountains was not different for different numbers of kids reared by the dam. Goat behavior was different for goats suckling two kids and not suckling probably because goats tend to act as a group, social behavior. Farmers can therefore use mountain grazing for kid rearing and benefit also in natural resource management (Baraza et al. 2009).

Conclusion

Goat kids can be reared by the dam and reduce the cost of kid rearing if the milk quota is filled and suckling period is adapted to grazing season. Kids reared by the dam compensate growth after weaning and catch up with single reared kids. The system will allow farmers to rear goat kids and sell as opposed to slaughter at birth. In addition, a slight reduction in milk yield by suckling dams becomes more profitable because of conversion to live weight gain for kids. And also, dam suckling doe not reduce the amount of milk yield after weaning. Farmers will obtain comparable milk with dam suckling

as none suckling goats. Therefore, dam kid rearing is profitable for milk production and cost saving on kid rearing which could provide extra income from goat sales.

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Paper II

Day and night grazing behavior and dam kid rearing on mountain pasture for Norwegian dairy goats

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Abstract

Seventy-five primiparous Norwegian does kidding in March were used in year 1 and year 2 of the experiment grazing systems on natural mountain pastures. In each year, lactating does were randomly allocated to day grazing (7 hours) only and day and night grazing (18 hours) systems based on age, date of kidding and number and sex of offspring. Lactating does were put on mountain pasture in the last week of June while rearing different numbers of kids (0, 1 & 2). The mountains lie between 950-1200 m above sea level. All kids were not supplemented and were housed separately at night. Does were milk twice a day in year one and once a day for suckling does in year two. In the first year, all does were supplemented a commercial feed at 0.4kg/day before putting them on mountain pasture. When put on pasture, concentrate in the first week was 0.4kg/day for day grazing only and 0.1kg/day for day and night grazing. In the following weeks, does on day grazing received 0.7kg/day while day and night grazing group, 0.4kg/day. Second year concentrate levels did not vary for different grazing system. All does received 0.4kg/day

before mountain grazing, reduced to 0.2kg/day in the first week of mountain grazing and there after 0.4kg/day. Twelve does in first year and twenty does in second year, suckling single kids were used in feed behavioral observations. Half of the goats in each year were of day grazing or day and night grazing system and were observed for 30 seconds for half an hour for activities and feed selection. During day time, one does of each grazing system was observed at particular time for each grazing group. Data was analyzed with SAS mixed models to compare behavior of does, kid growth rates, milk yield composition and Somatic cell counts. Day and night grazing gave higher (P=0.016) milk yields in second year (1.61 vs 1.38kg/day) and kid growth (P=0.019) rate (175 vs 160g/day) in both years. Goats on day grazing only engaged in more feeding activities (62% vs 55%) during the day unlike day and night grazing flock. Feed selection behavior was similar for both grazing systems and years of experiment. Therefore, day and night grazing could be a better management tool for optimal utilization of mountain pasture. It also allows for dam kid rearing of better kid growth rates. Moreover day and night grazing offer high milk yields.

Introduction

Livestock farming systems based on grazing on natural pasture benefit the farmer, environment but also human health. In Europe, mountain and forest pasture were used mostly for livestock production. A decline in farming activities which use the mountain pasture result in shrub forest vegetation invasion. Grazing systems are cost effective, produce healthier products and maintain traditional landscape. The grazing system is cost effective to modulate strong dynamics of vegetation towards shrub invasion (Casasus et al. 2003). Moreover, a properly implemented,

grazing management is a suitable tool to maintain traditional landscapes in protected areas and also capable to prevent forest fires (Kramer et al. 2003).

Milk, cheese and meat from natural pasture grazing systems is rich with micro-components(fatty acids and vitamins) and volatile compounds(flavors and terpenes) which favor human nutrition and health (Cuchillo et al. 2009; Galino et al. 2007; Morand-Fehr et al. 2007; Vasta et al. 2008). The system could be better paying for smallholder farmers if their products are recognized as healthier (Cuchillo et al. 2010). Better value for the product and addressing social challenges of population in mountain areas like being away from education, health care and economic infrastructures would promote grazing systems (Cohen et al. 2011).

Neglect of agriculture and subsequent transformation of landscapes into forest has resulted in ecological and social impact which makes sustainable development a challenge as report by Council of Europe (Europe 2000) and (Varga & Vila 2006). Transformation of landscapes into forest results in loss of mosaic landscape built by agriculture activity, and also its cultural values and variety of habitat increasing the risk of wild fires (Grove & Rackham 2000; Mac Donald et al. 2000). Agricultural activities like, goat grazing is a possible tool to maintain landscape.

Promotion of grazing systems for natural pastures is one of the sustainable development measure that will result in conservation, biodiversity and landscape protection and preservation of system, support livestock production that will contribute to biological diversity and cultural identity(Cohen et al. 2011). Furthermore, extensive livestock grazing is a useful instrument in the conservation of marginal areas and fulfills both social economical and environmental roles (Bernues et al. 2005). Use of goat in bush control and landscape management entails putting goats on natural pasture. Extensive grazing of goats on natural pastures require use of old and

experienced goat in the herd to lead the goat flock to best feeding sites (Miranda-de la Lama & Mattiello 2010). Leadership is animal's ability to influence the affiliative movements and activities of its group mates (Bouissou et al. 2001). Kid rearing of Norwegian goats on mountain pastures uses dam's experience in utilizing mountain pasture, maintaining landscape and bush control. Dam- kids rearing on pasture assist kid inexperience on pasture utilization (Biquand & Biquand-Guyot 1992; Gutierrez et al. 2007). Increase in grazing time of goat on natural is an alternative management tool which can allow goats to feed more on pasture and provide quality products for human nutrition.

In Norway, farmers graze goats on mountain pastures from end of June to September. Grazing goats on natural pasture maintain landscape and reduce feed costs by utilizing the available natural resource. Traditionally, Norwegian goats are bred for kidding around February and March and are put on pasture in May or June. Goat kidding in winter tends to utilize natural pasture after the peak of a lactation curve. In this study, we aimed at evaluating the effect of delayed kidding by kidding around April to ensure supply of good quality milk produced by goats grazing on natural pastures. We hypothesized that increasing grazing hours for goats would increase forage intake of grazing goats and allow for optimal utilization of natural pasture. Day grazing and day and night grazing systems were evaluated for milk yield, composition and quality along with grazing behavior and feed selection pattern to optimize utilization of natural pastures.

Materials and methods Materials and methods

Study site

The study was undertaken for two consecutive years and involved use of cultivated lowland pasture at the University farm with altitude of 150 m above sea level and latitude of 62' N and alpine (mountain) pasture located 350 km north of Oslo with altitude 900-1000 m above sea level and latitude of 62'18 North. The lowland pasture consisted timothy and Trifolium species while the major plant species in the mountain pasture were sedges in marsh areas, grasses and willow thickets (salix) and *Betula nana* in the drier areas.

Animals and management

The study was part of partial suckling experiment which focused on number of kids reared by the dam during mountain grazing (Chigwa et al. 2011). A total of 135 Norwegian dairy goats (66 and 69 in year 1 and 2, respectively) were used in the two year experiment. The goats were selected on the basis of age, date of kidding, litter size and sex of offspring's. The kidding season ranged from end of April to mid June. Animals were grazed on lowland pasture during the spring period (May/June, period A), mountain pasture during the summer (July/August, period B) and back to lowland pasture in autumn (September, period C). Does were allowed to graze together with their kids during spring period. At the beginning of mountain period does were divided into two groups of day and night grazing. Each grazing periods had three groups based on number of suckling kids (no suckling kid, one suckling kid or two suckling kids). Kids stayed with their dams during day time (0900-1500) and were kept indoors separately during night hours. In the

first year, dam concentrate supplementation for all dams in period A was at 0.4kg/day. At the beginning of period B (Mid July to August), dams on day grazing only continued concentrate supplement of 0.4kg/day while day and night grazing dam were fed 0.1kg/day. The lest of period B through to period C, concentrate levels for day and night grazing was increases to 0.4kg/day while day grazing only to 0.7kg/day. In year two all dams were on similar concentrate levels but varied with period. In period A, all dams were fed 0.4kg/day. In period B, concentrate reduced to 0.2kg/day and in period C it was up to 0.4kg/day. Day grazing goats were grazing for seven hours while day and night grazing flock grazed for 18 hours. After mountain grazing period all goats were grazing similarly in autumn. Therefore, autumn period had post treatment effects only.

Milk recording and sample collection

Goats were milked twice and once daily for suckling does (Year 1 and 2, respectively) throughout the experiment. Milk yield was recorded weekly on two subsequent days while milk samples were collected once weekly for analysis of chemical composition (fat, protein and lactose) and cell counts using Fossomatic method.

Milk samples were preserved with 2-bromo-2-nitropropane-1,3-diol and analysed for fat, protein and lactose using Combifoss instrument (Milkoscan 225 A/B and Fossomatic 250, Fosso-Electric, DK 3400 Hillerød, Denmark).

Body weight measurements

Body weight changes of does were measured four weeks before kidding, two days post kidding and every four weeks thereafter throughout the experimental period. Body weights of kids were taken shortly after birth and every four weeks thereafter till the end of the experiment.

Foraging behaviour

During the mountain grazing period 12 does in experiment one and 20 does in experiment two with single suckling kids were used to study foraging/grazing behaviour. In year one six does and in year two ten does were allocated to day grazing only or day and night grazing. All kids were housed separately from the does. The mountain period was divided into three sub-periods with three days in each. The observation was made on individual doe every 30 seconds for half an hour. The method has been described by Autumn (1974) as a 'Focal method' with 'Instantaneous sampling'. Day time observations were made in the morning and afternoon while night time observations were made in the evening. The various activities recorded included browsing, grazing, walking, standing, lying, ruminating.

Statistical analysis

Milk yield, milk composition, somatic cell counts, body weight measurements, foraging behavior data were analyzed using Mixed procedures of SAS (SAS Institute, 2003). Energy corrected milk(kg) was calculated as using milk yield, milk fat, milk protein and lactose as (0.01 x day yield of milk (kg) + 12.2 fat(kg) + 7.7 x protein(kg) +5.3 lactose(kg).

The model for milk yield, milk components and somatic cell counts analysis was:

$Y_{ijkl} = \mu + G_i + N_j + P_k + a_l + (GxN)_{ij} + (NxP)_{jk} + (GxNxP)_{ijk} + e_{ijkl}$

Where

Y_{ijkl} = milk yield/milk components/somatic cell count

μ = overall mean

G_i =Grazing time of the year at two levels (1= Mountain grazing, 2= Autumn grazing)

N_j =Number of kids suckled by dam at three levels (1= O kid, 2= 1 kid, 3 = 2 kids)

P_k =Grazing period at three levels (1= Mountain period 1, 11&13 July); 2= mountain period 2, 8 &10 August; 3= Mountain period 3, 28&30 August)

a_l = l^{th} effect of individual goats ($_{l=1....12/20}$)

$(Gx\ N)_{ij}$= Interaction of two effects (grazing time of the year and number of kids suckled)

$(NxP)_{jk}$= Interaction of two effects (number of kids suckled and dam and grazing period)

$(GxNxP)_{ijk}$= Interaction of three effects (grazing time of the year, number of kids suckled and grazing period)

e_{ijkl} = random effect of residual

The model for goat behavior analysis

$Y_{ijkl} = \mu + G_i + P_j + T_k + a_l + e_{ijkl}$

Where

Y_{ijkl} = behavior activity recorded

μ = overall mean of percent activity for whole observation period

G_i = Grazing system for goats at two levels (1= day grazing, 2= Day and night grazing)

P_j = time of the year when goats were observed at three levels (1= Mountain period 1, 11&13 July); 2= mountain period 2, 8 &10 August; 3= Mountain period 3, 28&30 August)

T_k = period of the day when observation was made at two levels (1= Day time (morning and afternoon); 2= Night time observation)

a_l = l^{th} effect of individual goats ($_{l=1....12}$)

$(Gx\ P)_{ij}$= Interaction of two effects (grazing system and Time when goats were observed)

e_{ijkl} = random effect of residual

Data analysis on grazing behavior for day and night and day grazing management system were compared for day grazing behavior and night time observations were ignored.

Results

Milk yield, composition quality and kid growth for day only day and night grazing systems on mountain pasture are presented in Table 1. Milk yield was high for day and night grazing does during mountain periods and in autumn in post treatment period for second parity. In the first year, milk yield was similar for both grazing systems and it increased in autumn, when kids were weaned, in the post treatment period. Milk fat differences were observed in primiparous does,

and was significantly (P=0.0001) higher for day grazing flock. In addition, somatic cell counts were similar for both grazing systems during mountain grazing in first and second year. Somatic cell counts increased in autumn in both year one and two, and in year two somatic cell counts were significantly (P =0.0008)higher for day grazing system.

Table 1. Milk yield and milk composition according to different grazing system and grazing periods (lsmeans).

Grazing period	Mountain		Autumn			P-value		
Grazing system	Only daytime	Day and nighttime	Only daytime	Day and nighttime	SEM	Grazing period	Grazing system	Interaction
Experiment 1:								
Milk yield, kg/d	1.55 [a]	1.56 [a]	1.93 [b]	1.79 [b]	.061	<0.0001	ns	0.076
Milk yield, kg ECM/d	1.31[c]	1.28[c]	1.79[a]	1.60[b]	.053	<0.0001	ns	.020
Fat, g/kg	30.6 [b]	28.1 [a]	38.9 [c]	36.4 [c]	.111	<0.0001	0.079	ns
Protein, g/kg	28.5[b]	28.7[b]	28.2[a]	27.3[a]	.044	.005	ns	.040
Lactose, g/kg	43.9[c]	44.8[b]	42.8[a]	43.8[a]	.042	.0011	.069	ns
Dry matter , g/kg	103.0[a]	101.6[a]	109.9[b]	107.6[b]	.141	<0.0001	ns	ns
Somatic cell count, x1000	135[a]	119[a]	1182[b]	864[b]	52.6	<0.0001	.007	.003
Kid growth rate(g/day)	160[a]	175[b]	-	-	0.0042	-	0.0196	-
Experiment 2:								
Milk yield, kg/d	1.38[d]	1.61[c]	1.29[a]	1.57[b]	.060	0.016	0.002	ns
Milk yield, kg ECM/d	1.08[c]	1.33[c]	0.864[a]	1.03[b]	.061	<0.0001	0.006	ns
Fat, g/kg	24.5[b]	26.2[b]	32.0[a]	29.9[a]	.093	<0.0001	ns	0.010
Protein, g/kg	29.6	29.6	27.6	27.9	.116	ns	ns	ns
Lactose, g/kg	41.2	41.7	40.9	42.2	.054	ns	ns	ns
Dry matter , g/kg	101.3[a]	106.6[a]	120.9[b]	123.0[b]	.502	<0.0001	ns	ns
Somatic cell count, x1000	1272[c]	1677[c]	2894[a]	1901[b]	308	0.0008	ns	0.0006
Kid growth rate g/day	180	176					ns	

SEM: standard error of mean; ns: non significance; letters in line indicate pairwise differences (5%)

Different superscript letters within a row denote significant differences.

Dam weight changes with day and night grazing

Dam weight changes are presented in Table2. Does on day and night grazing had significantly (P=0.0717) higher live weight end weight in the second year after mountain grazing period.

Table 2: Changes in dam live weight in different grazing periods for different numbers of kids suckled by dam

Dam live weight (kg)	Day Grazing	Night Grazing	SEM	P-values
Experiment 1				
Two days after kidding(kg)	47.08	48.13	0.5635	0.6382
(number of days)Spring live weight before mountain grazing(kg)	37.58	38.97	1.1978	0.4131
Mountain grazing end weight(kg)	40.72	42.27	0.9230	0.2418
Autumn live weights	40.53	40.75	0.5217	0.8798
Experiment 2				
Two days after kidding	52.67	51.28	1.6758	0.5601
Spring live weight before mountain grazing	41.61	42.01	0.8733	0.7495
Mountain grazing end live weight	40.36^{a}	41.82^{b}	0.5714	0.0717
Autumn grazing end live weights	42.60	43.49	0.8227	0.4455

SEM =standard error of mean; ns= non significance

Different superscript letters within a row denote significant differences

Grazing behavior for day and night grazing

Feed selection behavior of goats under day grazing only and day and night grazing were not different both year one and two during mountain grazing period (Table 3).

Table 3: Feed selection behavior for goat under Day grazing only and Day and Night grazing

Selected forages	Day grazing only	Day and Night grazing	SEM	P-Value	Significance
Experiment 1					
Grasses	44.27	40.49	3.0813	0.3831	ns
Sedges	11.39	11.78	2.1093	0.8947	ns
Grass-like	55.66	52.27	3.1144	0.4391	ns
Forbs	5.93	5.04	1.3814	0.6475	ns
Herbage	61.59	57.32	3.1048	0.3277	ns
Leaves	37.41	42.04	3.1371	0.2940	ns
Leaves and barks	37.43	42.14	3.1441	0.2860	ns
Juniper	0.59	0.24	0.2562	0.3338	ns
Fungi	0.05	-0.00	0.0435	0.3642	ns
Other plants	1.97	2.85	0.8149	0.4440	ns
Other sum	2.62	3.09	0.6500	0.6936	ns
Experiment 2					
Grasses	42.26	42.54	4.8902	0.9675	ns
Sedges	7.18	4.86	2.7091	0.5415	ns
Grass-like	49.44	47.40	5.5006	0.7912	ns
Forbs	5.29	3.68	1.5337	0.4545	ns
Herbage	54.73	51.08	5.5742	0.6404	ns
Leaves	44.74	47.77	5.5438	0.6965	ns
Leaves and Bark	44.74	47.85	5.5525	0.6892	ns
Juniper	0.46	0.52	0.4344	0.9217	ns
Fungi	0.03	0.17	0.1586	0.5542	ns
Other plants	0.92	0.96	0.3938	0.9404	ns
Other sum	1.42	1.65	0.5682	0.7883	ns

SEM =standard error of mean; ns= non significance

Different superscript letters within a row denote significant differences

Goat behavior for does on Day grazing only and day and night grazing are presented in Table 4. Significant differences were observed in the first year and not in the second year. In the first year, goat on day grazing only had significantly (P=0.0247) more feeding activity than day and night grazing does. The feeding behavior was mostly grazing (P=0.0360). Does grazing day and

night had more non-feeding activities (P=0.0212) and were standing (P=0.0283) more than day grazing only group.

Table 4: Variation in goat behavior day grazing only and day and night grazing

Behavior	N	Day grazing only	Night and Day grazing	SEM	P-Value	Significance
Experiment 1						
Feeding	12	62.13[a]	54.58[b]	2.3701	0.0247	*
Grazing	12	36.76[a]	29.40[b]	2.4753	0.0360	*
Browsing	12	25.18	25.12	2.1121	0.9826	ns
Non-feeding activity	12	37.86[b]	45.61[a]	2.3693	0.0212	*
Walking	12	30.02	33.77	2.0544	0.1949	ns
Standing	12	1.34[b]	4.32[a]	0.9583	0.0283	*
Resting	12	5.77	6.77	2.1347	0.7388	ns
Suckling	12	0.065	-0.004	0.0583	0.4014	ns
Other activities	12	0.67	0.75	0.2242	0.7979	ns
Sos other activities	12	2.08[b]	5.07[a]	0.9413	0.0332	
Experiment 2						
Feeding	20	60.17	53.01	4.4063	0.2412	ns
Grazing	20	29.57	24.71	3.8732	0.3644	ns
Browsing	20	30.56	28.06	3.6846	0.6244	ns
Non-feeding activity	20	39.77	46.79	4.3846	0.2485	ns
Walking	20	28.94	33.09	3.7540	0.4237	ns
Standing	20	1.76	2.86	0.8363	0.3407	ns
Resting	20	8.42	10.18	5.6128	0.8202	ns
Suckling	20	0.28	0.15	0.1584	0.5795	ns
Other activities	20	0.38	0.50	0.1512	0.5888	ns
Sos other activities	20	2.42	3.51	0.9159	0.3877	ns

SEM =standard error of mean; ns= non significance

Different superscript letters within a row denote significant differences

Goats fed on leaves and barks, leaves and forbs more (P=0.0001) in the morning than afternoon. In the afternoon, goat fed more on herbage, grass-like, grass, sedges unlike in the morning for both experiment 1 and 2.

The main(P=0.0001) grazing activity the morning was feeding (68% in experiment 1 and 75% in experiment 2) while non- feeding activities dominated afternoon grazing with 51% in experiment 1 and 61% in experiment2. The main feeding activity for morning time was browsing while in the afternoon there was more grazing in both experiment 1 and 2. The main (P=0.0001) non-feeding activity was walking in experiment 1 and resting (P=0.0001) experiment 2. More walking was observed in the afternoon in experiment 1 and more resting was observed in the afternoon for both experiments.

Discussion

1. Milk yield and composition

1.1 Day grazing and day and night grazing system

Milk yield of primiparous goats was not different for different grazing systems in pre weaning and post weaning period. In second parity, goats on day and night grazing gave more milk as compared to day grazing only both in pre-weaning and post- weaning period. The similarity in milk yield in primiparous goats was possibly because does in day grazing only compensate their nutritional requirements with the 300g increase in concentrate supplement. As such, the effect of more grazing hours was obscured by the increase in concentrate. Similar milk yields for goats exposed to naturally decreasing photoperiod and artificial photoperiod long days are also

reported in literature(Flores et al. 2011). In the second year, all doe were on similar concentrate supplementation level. Increase in milk in second parity for night and day grazing could be explained by increase feeding activity as compared to day grazing only. The increase in milk yield for day and night grazing does justify day and night grazing system as a better management tool to ensure optimal feed intake on natural pastures.

Energy milk was not significant during mountain period in experiment one. In experiment two, no differences were noted in mountain periods, while it increased for both groups in autumn. Goats were put on natural pasture when grass was in abundance. Therefore with day grazing alone, goats could meet all nutritional requirements. As pastures mature in autumn, nutritive value drops. As such, goats increase feed intake to meet their nutritional requirements. Day and night grazing allowed the goats to increase feed intake to compensate for low nutritive value of the natural pastures. In this study, the high energy milk for goats grazing day and night was high in autumn for second parity could be explained by increase in feed intake by increasing grazing hours. Increase in proportion of time allocated to feeding by goats grazing when forage nutritive value drops was observed for dry season grazing (Lin et al. 2011; Safari et al. 2011). Maturity influences forage nutritive value more than any single factor (Hassen et al. 2007). As forages mature, proportions of structural carbohydrates such as cellulose, hemicelluloses and lignin increase while crude protein decreases (Buxton & Fales 2004; Kozloski et al. 2005). Often, such forages have impaired rates of digestion for hemicelluloses and cellulose (Beever & Mould 2000)and limit intake by animals 1.2% of body weight as NDF (Mertens 1992). During grazing, when nutritive value of forage diminishes, animals have two options for covering nutrient requirements either by increasing intake or reducing the cost of feed collection (Vivas & Saether 1987) and grazing allows for increase in intake.

Milk composition changes were more on fat and not on lactose, protein and dry matter and somatic cell count. Milk fat was high in goats grazing day time only during mountain period in primiparous goats. Decrease in milk in late lactation is associated with increase in concentration of fat due to dilution effect (Morand-Fehr et al. 2007). Moreover, day grazing only and housing in summer elevates Melatonin levels by short -day photoperiod while increase in photoperiod resulted in a decrease (Dahl et al. 2000). Melatonin is released by pineal glands during darkness and inhibits secretion of the lactational hormone, prolactin by pituitary gland. Increase in Melatonin reduces concentrations of prolactin in blood plasma, reducing milk yield and composition as to that of late lactation (Auldist et al. 1998), therefore concentration of fat increased. Seasonal variation in milk yield and composition may be due to increased amounts of circulating melatonin in shorter days of photoperiod. Concentrations of prolactin increase with increase in day light (Peters & Tucker 1978); Buchanan et al 1993, (Dahl et al. 2000; Gustafson 1994) and long day photoperiod increases milk yield(Veliz et al. 2009). Prolactin is a peptide hormone controlling a variety of reproductive, immunological, developmental, metabolic and osmoregulatory processes (Ben-Jonathan et al. 2006; Bole-Feysot et al. 1998). Prolactin is produced by pituitary gland but secretion by other body parts is also reported in literature (Shibaya et al. 2006). At onset of lactation, prolactin conveys lipids towards mammary gland reducing their storage in adipose tissue and also affect lactose synthesis by coordinating an augmented uptake its precursor, glucose, with an increase in lactalbumin expression (Ben-Jonathan et al. 2006). In this study, we observed a significant increase in lactose in primiparous goats grazing day and night. The increase in lactose with day and night grazing could be explained by increase in prolactin with increase in photo period for day and night grazing in the Northern hemisphere where summer, grazing period, has long day light hours.

1.2 Grazing period

High milk yields were recorded for primiparous goat in autumn after weaning kids. In second parity, higher yields were recorded during mountain grazing. Mountain period gave higher protein and lactose in both year one and two. Late lactation, autumn period gave higher milk fat, dry matter and somatic cell count in year one and two. Increase in fat and total solids in late lactation is related to decrease in milk yield which result in high concentration of the components (Morand-Fehr et al. 2007). Late lactation is also associated with increase in somatic counts(Boyazoglu & Morand-Fehr 2001). In addition autumn period coincides with estrus period in the northern hemisphere and estrus is associated with high somatic counts (McDougall & Voermans 2002; Moroni et al. 2007). In this study, significant increase in somatic cell counts was also observed for day grazing only. Increase in somatic cell for day grazing group could be explained by the housing of goats at night as opposed to those on day and night grazing as for cows (Valde et al. 1997). Despite the increase in somatic cell count with day grazing, the levels observed were below minimum requirements of EU directives 92/46 and 94/71 (EU 1994), in first parity and above in second parity. The EU directive for the hygiene and bacteriological quality of goat milk's upper limit is 500,000 for products based on non-heat treated milk and 1500,000 for products based on heat treated milk. Norway uses EU standards for somatic cell count. Norwegian dairies(TINE 2011) have four classes of goats according to somatic cell count as Elite, below 1,500,000; 1 klasse between 1,501,000- 1,750,000; 2 klasse between 1,750,000-2,000,000; and 3 klasse for counts above 2,000,000. In this study, day and night grazing provides milk of low somatic cell count. In Norway, goat milk is mainly transformed into cheese and the composition of milk is an important factor in determining the quality of cheese (Vacca et al. 2010). In addition to providing good quality milk through day and night grazing, grazing

goats in autumn is good for bush controls bush for thorny bushes (Valderrabano & Torrano 2000)

2. Foraging behavior for goats

Goats on day grazing only had more feeding activity than those grazing day and night in experiment one (Table4). The goats grazed more in day grazing group unlike day and night grazing. Grazing behavior of goats shows that eating start soon after sunrise and increase during the day to reach maximum before sun set, thereafter becomes almost zero most of the night(Betteridge et al. 2010). Studies on anti predator theory (Rutter 2006), sheep (Birrell 1991) heifer (Hessle et al. 2008) and beef steers (Huber et al. 1995) indicate that animals avoid grazing during darkness because of perceived risk of predation. In our study, goats in day grazing only fed more because they wanted to ingest adequate forage within day hours as they had been housed over night unlike day and night grazing group. Day and night grazing does fed less in the day because they had more feeding time at night since summer has more light hours in the northern hemisphere. Goats in day and night grazing system engaged more in non-feeding activities than those in day grazing only. Non-feeding activities for day and night grazing does were mainly standing and other social activities.

3.0 Feed selection pattern for goats

Feed selection pattern was not significant different for grazing systems (Table 3). Increasing grazing hours did not change the feed selection pattern of goats probably due to high level of

social organization exhibited by most ungulates species (Matteillo 2001). Social organization behavior ensure cohesion of the flock(Fraser & Broom 1990), better protection from predators and better protection of neonates and also a negative effect of competition for feed resources where they are limiting (Estevez et al. 2007).In our study, all goats had access to a vast open natural mountain pastures. Moreover, goat preference for leaves and barks highlight their importance in bush control. Consumption of foliage and trampling by grazing animal reduce dead biomass which make the mountain prone to fire (Whalley 2005). With sufficient grazing pressure, to form grazing lawn, plants are maintained in a state of continuous regeneration (McNaughton 1984). In this study, an interaction of grazing period in the mountain and grazing system was not significant for grazing behavior and feed selection. This is may be due to the fact that the mountains were at very high altitude of 1200m above sea level and the goats accessed more and more fresh grass by going up the mountain where some snow had just melted as the forage quality was going down.

In our study, both day-grazing only and day and night grazing does were in the same flock during day- time grazing. Due to the social organization behavior of goats, no differences were observed in feed selection behavior of the two grazing systems. Probably, managing flocks on day grazing only and day and night grazing separately could be an alternative to observe the differences in goat behavior unlike observing them in same flock.

Feed selection pattern was significantly different for morning and afternoon grazing time for both experiments. Goats fed on leaves and barks, leaves and forbs more significantly in the morning than afternoon. In the afternoon, goat fed more significantly on herbage, grass-like,

grass, sedges unlike in the morning for both experiment 1 and 2. Some studies show that goats prefer grass in the morning and browse in the afternoon (Solanki 1994). The differences could be due to differences in temperature and elevation and goats' preference for broom. In heterogeneous vegetation, shrub species are selected when they offer more palatable organs like flower in broom(Ammar et al. 2004; Frutos et al. 2002) Broom provide protein rich fodder as a supplement to more fibrous herbaceous biomass(Tolera et al. 1997).

4.0 Doe and kid weight changes with day only and day and night grazing system.

Goats grazing in day and night regime lost weight in autumn in year one but attained higher end live weight in year two(Table 2). Both groups lost weight in spring with more losses for day grazing group in year two. Weight losses in spring for both groups is associated with mobilization of body reserves for milk production in early lactation (Dunshea et al. 1990). In year two, increase in feeding for day and night grazing group observed in this study, coupled with reduced weight losses from for milk production would explain the gain in end live weight. Reduced weight losses in mature lactating animals and corresponding increase in milk yields was also observed for cows (Eslamizad et al. 2010).

Kids reared by dams under day and night grazing grew more than those of day grazing only. Goats on day and night grazing had increased feeding activity which might be reflected in kid growth rates as observed in the study.

Conclusion

Day and night system for goats grazing on natural pastures is an alternative management tool for optimal utilization of natural pasture, increased milk yields and better kid growth and offer milk of low somatic cell counts. Day and night grazing allowed does to meet their nutritional requirement with increased feeding time. In addition, kid growth rates realized with day and night grazing were higher than of kids from dams of day grazing only. Moreover, milk yields were also higher with day and night grazing and also milk was of low somatic cell counts. Therefore, day and night grazing is a better management tool for optimal utilization of mountain pastures, and which can reduce concentrate cost for dairy goat farmers while offering higher kid growth rates, milk yields and improving milk quality.

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Paper III

A comparison of dam and machine suckling kid rearing for Norwegian dairy goats

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Abstract

Dam partial suckling and automatic machine suckling methods were assessed for pre-weaning and post-weaning growth rates on natural pasture for Norwegian dairy goat kids in 2005 and 2006. In 2005, One hundred and twenty eight kids were allocated to dam partial suckling (52) and automatic machine suckling (76) while 2006 experiment used 45 and 46 kids on dam and automatic machine rearing respectively. All kids were reared by the dam for three days and from day four to weaning at six weeks, kids were put on different suckling methods. Dams suckling kids were milked once a day, in the morning, and those with kids on automatic machine were milked twice. Automatic machine reconstituted a commercial milk powder (20% CP and 11NEL/kg) in portions of 0.3-0.5 litres and kids suckled through 6 teats. All dams were fed on silage at 10% refusal rate and concentrate. Kids on automatic machine had access to kid concentrate (18%CP) and hay (11%CP) ad libtum while dam suckled kids were creep fed the same. Kid's monthly weights from birth to weaning and monthly weights in post weaning period were

recorded. Milk yields, time and activities when rearing kids on automatic machine were also recorded. Pre-weaning kid growth rates were higher for dam reared kids (190g/day vs 146g/day in 2005 or 184g/day vs 146g/day in 2006 and similar to automatic machine reared for post weaning on pasture(94g/day and 100g/day in 2005 and 98g/day and 93g/day in 2006). Time spent with kids on automatic machine decreased with time as kids got used to the machine. Kids reared on the machine were more stressed and attained lower growth rate by 51g/day for males and 25g/day for females. Milk yields of suckling and none suckling dams was comparable but non-suckling dam's lactation curve was more persistent.

Dam kid rearing offers optimal kid growth and better returns at selling goat kids for meat. However, automatic suckling machines offers alternative rearing method of replacement stock and goat kids for meat while allowing farmers to benefit more from winter milk sales.

Key words: suckling, automatic machine, kids, stress, rearing, Norwegian.

1. Introduction

In Norway milk is the major product of the goat industry. Kidding normally takes place in February and the goats are barn-fed until start of grazing in May or June. The grazing on the natural range pastures ends in September or October. The goats are then milked for a period of 1 - 3 months and dried off 2 - 3 months before parturition. The

result of this system is peak deliveries of milk from April to September and shortage during mid winter.

A new brand of cheese «Snøfrisk» (i.e. Snow-fresh) is marketed locally and abroad. «Snøfrisk» is a white spreadable cheese, which can be stored for only three months. Producing the cheese requires even supplies of high quality milk throughout the year.

Traditionally, partial suckling is used by Norwegian goat farmers to ensure kid rearing for replacement stock and milk supplied to the dairies. In partial suckling, goat kidding in February suckle kids exclusively in the first three days thereafter dams are milked once a day until kids are weaned at 6 weeks. After weaning dams are milked twice a day until drying- off period.

Partial suckling in pre-weaning period saves farmers time for evening milking but reduces amount of milk delivered to the dairies. A reduction in milk supply to the dairies is costly when pre-weaning period falls in periods of short milk supplies for dairies. Alternative kid rearing systems like automatic suckling machines would increase amount of milk delivered to dairies.

Automatic suckling machines have been used to reduce labour and allow for flexible approach in feeding and increase milk supplies for calves (Roth et al. 2009). Automatic suckling machines are also preferred because the machine allows for suckling. Nipple suckling allows the milk to pass directly into the abomasums (Friend & Dellmeier 1988; Wise & Anderson 1939). Higher weight gains for calves (Schiessler et al. 2002) and lambs (Bimczok et al. 2005) are reported in literature. Literature has few studies

using small numbers of kids on automatic suckling machine (Keskin 2002; Piasentier et al. 2000) and hence cannot be used by farmers with larger flock size.

Therefore, the objective of this study was to compare the feasibility of partial suckling with automatic suckling machines in kid rearing for replacement stock and males for meat, and post-weaning growth rates on natural pasture.

2. Materials and methods

2.1 Study site

The study was done for two consecutive years under goats were confined during kid rearing period at goat house pens under the university farm with altitude of 150 m above sea level and latitude of 59°40' North. After weaning at 6 weeks, kids were raised on alpine (mountain) pasture located 350 km north of Oslo with altitude 900-1000 m above sea level and latitude of 62°18' North. Major plant species in the mountain pasture were sedges in marsh areas, grasses and willow thickets (salix) and *Betula nana* in the drier areas.

2.2 Animals and management

A total of 120 Norwegian dairy goats were bred for kidding around April in 2005 and 2006. The goats were allocated dam rearing or automatic machine kid rearing on the basis of age, date of kidding, litter size and sex of offspring's. . Kids born were allocated to dam rearing or dam rearing for three days plus automatic feeder rearing until 6 weeks

of age. In 2005, 52 kids were reared on automatic suckling machine and 76 kids were reared by the dam. A total of 69 male and 59 female kids that were used in the experiment born as singles were 27, twins were 84 and triplets were 17. The study was repeated in 2006 using 45 and 46 kids on automatic machine and dam suckling respectively.

Dams with kids on automatic suckling machine suckled kids in the first three days after kidding and were permanently separated. Goats were milked at 06:30 hours and at 16:00hours each day. Dams with kids on automatic machine were milked twice a day while dams rearing kids were milked once per day. Kids reared by the dam were suckled after morning milking, 09:00-16:00hours and separated whole night.

Animals were fed indoors during suckling period and kids were put on pasture soon after weaning at 6 weeks. Pregnant does were supplemented with a concentrate that was gradually increased to 0.5kg/dam before kidding. After kidding the does were supplemented with a commercial concentrate mixture high in fibre to 1kg/animal. The dams were fed concentrate of 17.4% crude protein and 703 NEL/kg (Net Energy of Lactation per kilogram of concentrate) and silage of 22% crude protein at 10% refusal rate. NEL was calculated from Feed energy Milk (FEM) of concentrate provided by the feed manufactures using 1 FEM= 6.9 NEL of concentrate.

All kids had access to kid concentrate of 18% crude protein and 642NEL/kg up to when they could consume 0.3 kg per kid and fed hay of 11% crude protein was offered ad libitum. Kids reared by automatic suckling machines, Forster Technik (Art Nr 30070, TAK5-SA2-32-P1/230, number 335543, made in Germany) were fed using powdered milk of 20% crude protein and 11NEL/kg. The machine mixed 0.3-0.5 litres of milk

portions using powdered milk and warm water. Warm milk for the mixer was dispersed through tubes connected to 6 feeding teats. Experiment 1 used 400kg of powdered milk to rear 56 kids from day 4 to weaning at 6 weeks. In the following year, 321kg of powdered milk was used to rear 45kids from day 4 to weaning at 6 weeks.

Kids were trained to suckle on the suckling machine by first suckling them in bottled teats while practicing to suckle alone on suckling machine for two days. The kid was not supplemented with bottled milk on the third day and when very hungry resorted to attempt suckling on the machine alone. Automatic suckling machine was refilled with powdered milk every morning and when it was empty. Milk reconstitution chamber and pipes were cleaned every morning and teats were changed where any linkages were observed. Bedding straw or sawdust was changed every day to ensure that kids are reared in a dry room. The kid rearing pen was kept warm and had playing materials for the kids. Hay, concentrate offered to kids on automatic suckling machine was also creep fed for kids suckled by the dam. Hay and kid concentrate was fed ad libitum.

All husbandry practices like dehorning all kids and castration of male kids were done within 7days of age. Treatment of sick kids was carried out on both dam and machine reared kids. After weaning, at 6 weeks of age, all kids were reared on pasture to market weight at (47 weeks), for excess male and breeding age for replacement females.

2.3 Data and records

Time spent in the kid rearing pen for each activity was recorded. Birth weight, weaning weight and fortnightly weights of kids were recorded. Records of kid birth date and weight, weekly weights, monthly weights when on pasture; time spent with the kids was recorded through-out the experimental period.

2.4 Statistical analysis

Data collected was analyzed using Statistical analytical package (SAS) and frequencies were derived for summary of data and analysis of variance was used test to test the means for significance.

The following models were used:-

$$Y= \mu+S_i +W_j + B_k + D_l +T_m+\Sigma_{ijklmn}$$

Where Y= Pre-weaning Weight gain

μ= Overall mean effect

S_i = Suckling method to the $_i$th effect

W_j= Weaning age to the $_j$th effect

B_k= Birthweight to $_k$th effect

D_l= Kid sex to $_l$th effect

T_m=Litter size at suckling to $_m$th effect

Σ_{ijklmn}= Random Error

(ii) $Y= \mu + S_i + W_j + B_k + D_l + T_m + A_n + \Sigma_{ijklmno}$

Where Y = Pasture weight gain

μ = Overal mean effect

S_i = Suckling method to the $_i$th effect

W_j = Weaning weight to $_j$th effect

B_k =Birth weight to $_k$th effect

D_l = Kid sex to $_l$th effect

T_m = Kid sex to $_m$th effect

A_n = Weaning age to $_n$th effect

$\Sigma_{ijklmno}$ = Random error

(iii) $Y= \mu + S_i + W_j + A_k + \Sigma_{ijkl}$

Where Y = Unit Price per kilogram (Kroner)

μ = Overal mean effect

S_i = Suckling method to the $_i$th effect

W_j = Weaning weight to $_j$th effect

A_k = Weaning age to $_k$th effect

Σ_{ijkl} = Random error

Results

Pre-weaning growth rate of kids was significantly higher for dam reared than automatic machine suckled kids. However, post-weaning kid growth rate on pasture were similar for both kid rearing systems (Table 1).

Table 1
Performance of kids reared by dam and Automatic suckling machine in 2005 and 2006

Parameter	**N**	**Dam rearing**	**SEM**	**N**	**Automatic suckling machine rearing**	**SEM**
Experiment 1						
Powdered milk used to weaning kg/day		0		56	10.3	
Mean Birth weight (kg)	85	3.2± 0.55		56	3.3± 0.49	
Mean weaning weight(kg) at 6 weeks	74	13.1±3.15		52	8.4±2.42	
Lsmean of Pre-weaning weight gain(g/day)	74	190[a]	5.0092	52	146[b]	5.5345
Mean end weight on pasture(kg) 6months	74	24.0±3.63		52	20.8±2.07	
Lsmean of Pasture weight gain(g/day)	74	94	3.6425	52	100	4.9068
Experiment 2						
Powdered milk used to weaning kg/day		0		45	8.3	
Mean Birth weight (kg)	48	3.1±0.51		45	3.2±0.50	
Mean weaning weight(kg) at 6 weeks	46	12.6±2.20		45	11.0±2.00	
Lsmean of Pre-weaning weight gain(g/day)	46	184[a]	5.0092	45	146[b]	5.3580
Mean end weight on pasture(kg) at 6 months	39	27.0±3.74		14	24.9±2.98	
Lsmean of Pasture weight gain(g/day)	39	98	3.8767	14	93	5.9500

Lsmean which have different superscripts within a column are statistically significant; S.E= Standard error.

3.1 Weight gains for kids reared using different rearing systems

Pre-weaning weight gain was significantly different for kid suckling method and sex ($P<0.0001$). Kids suckled by automatic machine lost 43g/day with a standard error of 6.7040 in experiment 1 and 51g/day with a standard error of 9.0637 in experiment 2 compared to dam suckled kids. Differences in weight gain were also observed for kid sex. Male kids gained 22g/day in experiment 1 and 29g/day in experiment 2 more as compared to female kid during the whole experimental period.

3.2 Time spent with the kids

Time spent with the kids on automatic machine was considered by analyzing the trend in time spent with the kids when there were a constant number of kids using the automatic machine.

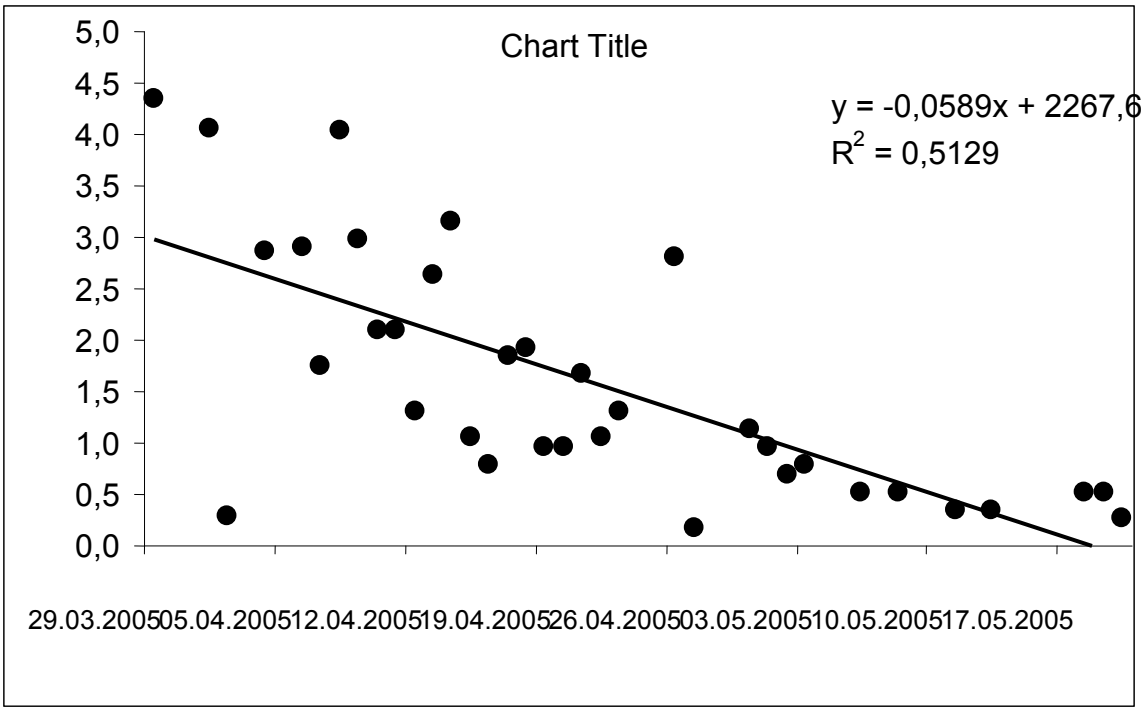

Figure 1: Trend in Minutes spent per kid for kids reared using automatic suckling machine

As the kids were getting used to the automatic milking machine, there was a decrease in time spent by attendants. Changes in time (minutes) spent per kid as time progress is expressed as:-

$$Y = -0.0589 X + 2267.6;$$

Where, Y is minute spent per kid and X is time period and a constant of 2267.6.

On the other hand, dam kid rearing allows the farmer to save evening milking time because of once milking. Once milking allows for flexible farmers time during kid rearing unlike twice milking tradition.

3.3 Ability of kids to cope with stress

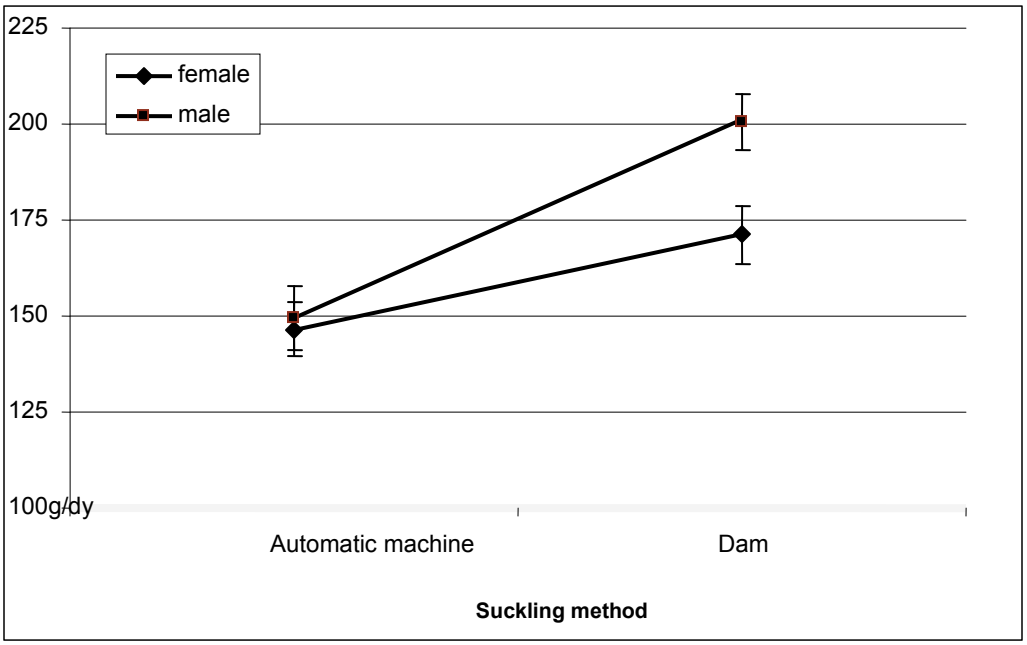

Figure 2: Graph of Growth (g/day) of male and female kids reared on automatic suckling machine and dam suckling method in 2006.

Male and females kids reared using automatic suckling machine attained lower growth rate by 51g/day and 25g/day respectively as compared to kids suckled by the dam. The results show that male kids were more stressed on automatic suckling machine as compared to females.

3.5 Weight from pasture

Table 5 shows pasture weight gains for 2005 and 2006 that were not statistically significant. Female kids that were reared using automatic machine in 2005, showed higher pasture weight gains than dam suckled. Kids that were on the automatic machine gained 6g/day with a standard error of 6.7961 standard error in experiment1 and 5g/day with a standard error of 6.8239 in experiment2 more than dam suckled kids. Post weaning growth rates in experiment2 were affected by sex of the kid. Female kids grew 4grams less per day with a standard error of 7.2015 than males.

3.6 Milk yield persistency

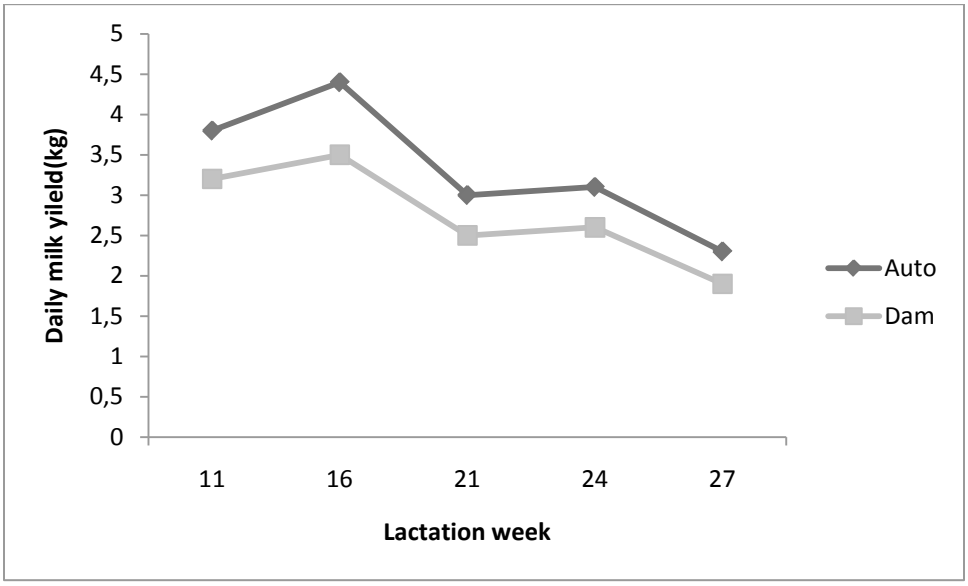

Figure 3: Daily mean milk yield persistency (kg/day) for different kid suckling regimes

The daily milk yields (Table 6) showed significant differences for lactation week 11 and 16 ($P<0.001$) and no significance for week 21 24 and 27.

The daily milk yields show a persistence of the lactation curve for dams whose kids were reared using automatic suckling machine unlike using the dam. The daily milk yields could not be used for economic analysis for milk powder utilization because the measurements were taken after the kids were already weaned.

4. Discussion

4.1 Pre weaning kid growth rates

Dam kid rearing gave higher kid growth rate than automatic kid machine suckling. Our findings agree with kid growth rate of Creole kids and Canary kids (Arguello et al. 2004; Perez et al. 2001). Kids on auto had to cope with stress of being detached from the dam, learning to suckle teat and training to suckle independently on machine. Their stomach had to get used to artificial milk Replacer which could be cold milk for small amounts which remained in the pipes. Earlier days of machine suckling, kids had diarrhea, probably due to cold amounts of milk ingested before fresh warm milk is sucked from the milk mixer. Diarrhea was also observed in the last days on the suckling machine as kids ingested too much milk of the automatically reconstituted milk. Unlike dam suckling, where kid stop suckling when the udder is empty; kids on automatic machine could suckle as much as possible. As kid grew, intake of milk was increased at the expense of rumen space for grass hay and concentrate that was offered adlib resulting in scours. High milk replacer intake resulted in stomach upset and diarrhea. Diarrhoea condition which result from high intake of milk replacer causes metabolic acidosis. Metabolic acidiosis promote weight loss and not weight gain in humans and calves (Berkemeyer 2009; Vajda et al. 2007). Diarrhoea in kids increase Na+ and Cl- and increase K+ along with increase in Aspartate aminotransferase (AST) (Sobiech et al. 2005).Changes in the acid base balance, damage of muscles as indicated by increase in AST seem to explain the low growth rates when kids have diarrhea. In addition to scours, low kid growth rates

could also be explained by lack of growth promoters in milk replacers as compared to dam's milk (Baumrucker & Blum 1993). Milk replacers also have lower digestibility than dam's milk, which in turn result in low growth rate for kids reared on milk replacers (Sanz Sampelayo et al. 1990). These findings are different from those by (Keskin 2002), who reported no significant results and Schiessler et al., (2002) when working with Damascus goats and calves respectively where milk replacer had similar energy to dam's milk. The findings are similar to Louca et al., (1975), who reported a low growth rate of artificially reared kids weaned at 35 days as compared to 70 days when working with Damascus goats. The low growth rate for kid reared on automatic machine could also be due to kid behavioral changes and the stress the kids had to go through as kids were separated from the dam and getting used to the machine. On the contrary, kids that were suckled by the dam were not subjected to any stress in relation to feeding system and environment and kids grew better than using automatic machine. The technology of Automatic suckling machine operation could be improved to reduce kid scours from cold milk in earlier days and when they are grown by installing a warming facility for reconstituted milk and electronic code for individual kids' intake. The modification will allow kids to suckle warm milk as they learn to use the machine and reduce excess intake of milk as kid grow up. A similar automatic suckling machine is promoted for calves for similar attributes by Seipelt et al., (2003).

4.2 Time spent on kid rearing using automatic suckling machine

Unlike saving time in kid rearing and reducing milk supplies with partial suckling, automatic suckling allows for labors saving with time and increase amount of milk supplied to dairies. Time spent with the kids decreased as rearing period progressed. The first days when kids were on automatic machine, they required more time to bottle feed and train to suckle individually. Some learned faster than others which were very scared of teats and with time they could suckle due to hunger as they saw others do it. Some had the challenge to allocate teats and ended up straggling for one teat from which each could suckle based on their effort to out-compete others. The other times with the kids were for changing teats which got broken in the suckling learning process resulting in leakage of milk. Other than changing teats, more time was also spent changing beddings, cleaning the automatic suckling machine, feeding and refilling milk powder. As kids grew up most of the time was on feeding, refilling milk powder, changing beddings as need be and cleaning the machine daily. Time spent with the kids on automatic suckling machine reduced gradually as kids learned to suckle independently. The reduction in time spent in training newly introduced suckling young ones on the automatic suckling machines was also reported for calves by Jensen, (2006). The decrease in time requirement on rearing kids using automatic suckling machine offers solutions to rearing excess kids in a dairy herd when a farmer wants to engage less time on the farm and do off farm work. As such, farmers will require less and less time to manage kids reared using an automatic suckling machine. When less of the farmer's time is allocated to kid rearing, farmers will relieve their time for other income generating activities. Hence use of automatic suckling

machines will relief the dairy goat farmers off some labor that can be used more efficiently where the farmers feel fit. On the other hand, dam kid rearing relieves the farmer of time for evening milking.

4.3 Kids and stress on automatic suckling machine

Kids reared on automatic suckling machine were more stressed than dam reared kids. Kid suckling seems to explain the differences in stress for dam and machined suckled kids. High oxytocin levels were reported in restricted suckling calves compared to bucket fed calves with and without mother contacts (Lupoli et al. 2001). Oxytocin provides anti-stress effect like decreased blood pressure and lower cortisol (Uvnas-Moberg et al. 2001). In addition, research with rat and human has shown that suckling induces calming effect in newborns (Blass 1994).

Male kids grew faster than females on dam and automatic suckling method. Comparing the kid growth rate within sex for the different suckling methods, male kids were more stressed on automatic suckling machine than females. Male kids had more stress in coping with new feeding system and environment than female kids. Similar results were reported when comparing mature and immature male mice (Hermes et al. 2006).Hormonal imbalances during stress period in males and females reflect in behavioral differences and ability to cope with stress. Similar trends were observed for human beings.

4.4 Post weaning kid growth rates on pasture

Despite the low pre-weaning growth rate in kids reared by the automatic suckling machine, when put on pasture, kids gained more weight to catch up for the low pre-weaning growth rates. As such the pasture weight gains were not significant for suckling method. The kids on automatic suckling machine coupled up easily on introduction to pasture as they had done away with the stress of being detached from the dam unlike dam suckled kids. Kids that were reared using automatic suckling machine exhibited compensatory growth on introduction to pastures by attaining comparable growth rate to dam reared kids. Kids weaned on the automatic machine had compensatory growth while dam suckled kids were undergoing stress of dam separation, feed and environment which the auto kids had done away with and were independent. Similar results were reported for alpine male kids that were reared by single suckled dam and artificial milk Replacer whose live weight and carcass traits were not significantly different. Post weaning growth rate and unit price of carcasses (10 versus 8 Nok/kg) were better for dam suckled kids. The gain of half a kilo in milk for dam not suckling appears not to offset the higher pre-weaning growth rates and the 2 Nok gain per unit kilo of kid meat. Therefore, kids are better reared by the dam. However, artificial suckling method could be used in rearing replacement stock and excess male kids where the cost of milk replacer, labor for twice milking, training kids to suckle on machine can be offset by more revenue from surplus milk sales.

4.5 Milk yield persistency

Milk yields of dams that suckled was comparable to dam that did not suckle despite lactation curve persistence for dams not suckling. Some differences were observed in the short term at lactation week 11 and 16 unlike in following lactation weeks. The results agree with Peris et al., (1997). The findings also agree with Bar Peled et al., (1995), where dams with kids on artificial rearing system could hold 60-70% of milk in between milking. Therefore, artificial kid rearing systems are being researched based on the findings that separation of kids from dam at birth for dairy goats does not affect total lactation performance due to minimal importance of neuro-endocrine milk reflex in goats as compared to other ruminants (Peris et al. 1997). The differences observed in lactation week 11 and 16 are centrally to research with cows where suckling gave a short term increase in milky yield (Akers 1985; Hillerton et al. 1990)and Bar Peled et al. (1995) and Marnet et al. (1999) reported that suckling and frequent milking in early lactation enhance mammary development (Hale et al. 2003), increase both mammary proliferation and mammary cell differentiation in ruminant. In goats, mammary proliferation continues for the first few weeks postpartum (Knight & Peaker 1984) explaining the differences in trend observed in our study. Increase in milk for suckling does could also be explained by dam-young contact (Hernandez et al. 2007). On the contrary, kids on suckling machine were separated from the dam at 2-days old and dam got used and produced additional milk. Dams easily lose links with kids after 24hrs of separation and may need to re-establish maternal link after long hours of re-union (Ramirez et al. 1996).

Conclusion

Dam kid rearing offers optimal kid growth rates, better returns when kid are put on pasture while automatic machine milking offers more income when milking goats in winter. Moreover, automatic machine could be an alternative when measuring farm profitability based on prices of milk and body weight of kids. Despite the low growth rates attained at weaning, female kids on automatic suckling machine attained even higher growth rates than dam-reared kids which give farmers alternative rearing method that does not affect post weaning kid performance. The ability of kids reared on automatic machine to catch up on pasture gives possibilities of rearing male kids for meat using less demanding technology. Moreover, farmers rearing kids on automatic machine in winter would benefit from high milk prices than other months.

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Paper IV

Effect of kid rearing system on farmer's available milk, milk composition and kid growth rate of pure Norwegian dairy goats reared in Tanzania.

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Abstract

Innovative ways of sharing milk between humans and goat kids have been developed by local farmers. This study aimed at evaluating three popular kid suckling methods for milk yield, kid growth and milk composition using pure Norwegian goats reared in Tanzania using 18 and 12 does in 2008 and 2009 respectively. The methods were: I) One teat milking and one teat suckling and milking twice daily; II) Milking in the morning only, combined with suckling during day-time and separation of kids at night and III) Early weaning of kids and milking twice daily. Daily milk yield and feed intake was recorded and milk samples were collected every fortnight. Weekly kid weights and monthly dam weights were taken in both experimental periods.

Daily milk output was significantly (P=0.003) higher for twice milking and artificial suckling in Experiment 1 than one teat milking and one teat suckling and once a day two teat milking (1082, 872 and 731ml).On the contrary, daily milk output (56days) was

similar in experiment 2 for one teat milking plus one teat suckling, two teat one milking and whole day suckling; and twice milking two teat plus kids artificial suckling (875, 981 and 851mls) in experiment 2. Daily farmer's available milk was significantly higher (P=000) for Suckling goats (one teat milking plus one teat suckling, and two teat milking once a day) than none suckling (twice a day milking both teats and kids bottle fed) as 862ml for one teat milking, 731ml for once a day milking and 387ml for twice milking and artificial feeding dam's milk. Similarly, farmer's milk in experiment 1 was 875ml for one teat milking, 981 for once a day milking and 350mls for twice milking per day in experiment 2. Daily kid growth rate was not significantly different in both experiments for teat suckling and one teat milking; once a day milking and kid suckling whole day and twice milking with kids artificially fed dams milk in experiment one (73g, 66g and 62g); and experiment 2 (53g, 38g 51g). Furthermore, milk butter fat was higher for none suckling goats in experiment 1 (P=0.005) and higher for two teat milking in experiment 2(P=0.002). Milk butter fat for experiment 1 was 4.1% for one teat milking, 4.0% for once a day milking and 5.1% for twice milking. However, in experiment 2, milk butter fat was 3.3% for one teat milking, 5.2% for once day milking and 4.5% for twice milking. Overall, once a day milking increased milk butter fat by 45% (5.17 vs3.74%) than twice a day milking. Milk protein was not significantly different for different milking and suckling regimes in both experiment one (3.1%, 3.6% and 3.2%) and two ((3.5%, 3.6% and 3.8%). Total solids were higher for once a day milking in experiment two (11.7%, 13.5% and 12.9%) whereas experiment 1 gave higher total solids for twice milking (P=0.002) as 11.8%, 11.9% and 13.5%.

Pure Norwegian goats can be reared with one teat milking and one teat suckling; and two teat once milking and kid suckling whole day and provide higher daily farmer's available milk and comparable daily kid growth rate than twice milking two teats and bottle suckling kids. Two teats once milking is labor saving and provide higher total solids, milk butter fat and comparable milk protein to one teat milking and twice milking. Once day milking provides better quality for milk processing and could be adopted used with consideration where a dam has twins. Moreover, once day milking provides extra daily income from sales of fresh milk (504; 84 Tzs) compared to twice milking and one teat milking.

Introduction

Kid rearing management practices that allows for optimal growth, reduce mortality rate and provide goat milk utilization are attractive to dairy goat farmers. In Tanzania, dairy goat farmers are using indigenous knowledge that 'goat kids suckle one side and dams withhold milk for kids' to balance for milk utilization and kid growth. This indigenous knowledge is also being used in rearing of Norwegian dairy goats which were introduced in Tanzania in recent years. The goats have become popular and innovative ways of sharing milk between human and goat kids have been developed by local farmers. They have developed different methods of optimizing kid suckling and milk output for household use. Milk yield and quality is mainly regulated by milking frequency if feeding, welfare, health and environmental conditions are adequate (Marnet & Komara 2008). Tanzanian farmers employ a method of milking one teat and leave the other teat

for kid. Other farmers milk both teats and allow the kid to suckle whole day and take it away at night.

Kid rearing methods of one teat suckling or suckling after milking is driven by farmers' traditional knowledge that a suckling dam will withhold milk in the udder during milking and release it to the kids at suckling. The farmers knowledge agree with physiological work which demonstrated that mother-offspring bond and maternal behavior strongly inhibited oxytocin release at milking but did not affect prolactin and cortisol release in goats (Hernandez et al. 2007), ewes (Marnet & Negrao 2000) or growth hormone release in cows(de Passille et al. 2008). The methods allow contact of kid and dam and ensure that the kid suckles warm milk. On the other hand, bucket feeding of kids allow the kid to grow in isolation from the dam. Bucket feeding requires prompt consumption to ensure that the kid get warm milk and care to reduce milk contamination. But, bucket feeding method, where kids are reared on milk replacer, allows for high milk production for household use.

Norwegian dairy goats are being promoted to smallholder farmer in Tanzania to increase milk production since 1988. Previous dairy goat breeds introduced include Kamorai in 1930 and another wave of importations was in between 1960-1980 with Saanen, Toggenburg, Anglo-nubian and Alpines (Mtenga & Kifaro 1992). Despite high milk yields and kid growth rates as compared to local goats, mortality rates of 9-54% were reported. Milk yields of pure Norwegian goat at SUA were 1.1±0.4 and 1.1 ± 0.21 at on farm in Mgeta and birth weights were 2.0+-0.6kg and pre-weaning weights was 45±20kg

at SUA (Mtenga & Kifaro 1992). Traditional goat rearing is characterized by low survival and high mortalities. Kid mortalities of 37% were observed for communal rearing systems in South Africa (Sebei et al. 2004). Kid mortalities are reported for pre-weaning and post weaning period. Kids are monogastrics in the first month and therefore depend on dam milk for survival (Castro et al. 2009).

Optimal sharing of goat milk between the farmers and the kid has a greater driving force as goat milk is becoming more and more important to human nutrition. Sixty percent of the poor people's income is from livestock (Devendra 2006). Goats are preferred for their resilience and ability to produce under different conditions (Silanikove 2000). Farmers in Mgeta in Tanzania are benefitting from rearing half bred dairy goats for milk and for sell of breeding stock. In Africa goat milk is recommended for sick and weak especially by those affected by HIV/AIDS (De Vries 2008). Goat milk is a cradle of modern civilization in human nutrition ((Hatziminaoglou & Boyazoglu 2004). Compared to cow's milk, goat milk is 4-5 times higher in oligosaccharides (Martinez-Ferez et al. 2006); 20-40 fold high in taurine which is used in bile salt formation, calcium transport, antioxidation, central nervous system and osmoregulation and essential in infant formulas (Bouckernooghe et al. 2006; Mehaila & Al-Kanhal 1992; Redmond et al. 1998), and high in nucleic acid which facilitate immune system maturation in offspring feeding on milk (Prosser et al. 2008).

Therefore, the main objective of this study was to investigate the effect of traditional kid suckling regimes on farmer's available milk, milk composition and kid growth rate for pure Norwegian goats reared in Tanzania.

Methodology:

Study site

The study was conducted at Mulbadow farm of Haydom hospital which is located in Hanang District in Manyara region in Tanzania**.** The farm lies at 35˚ 12′ E, 04˚ 25′ S. Average annual rainfall at the farm is 408-802mm. Rain fall season is December to May while dry season is June to December. Minimum temperatures of 10^{o}c and maximum temperatures of 29^{o}c are experienced at Mulbadow farm. The goats were bred to kid in cool dry season (July to October). However, kidding of goats in 2009, experiment 2 spread to hot dry season (November to December). The farm is used as a breed multiplication farm for Norwegian goats were introduced in Tanzania for dairy goat improvement program. The head is managed by Mulbadow farm which supplies goat milk to Haydom hospital.

Treatments

Eighteen and twelve lactating does were used in experiment 1 and experiment 2, respectively. Three treatments were randomly allocated to the does using kidding date,

litter size and doe's weight. The treatments were twice milking one teat and one teat suckling kids; once milking both teats and suckling whole day; and twice milking both teats and bottle feeding kids 300ml milk at each milking. The does were 18 months old and in first parity in experiment one, and second parity in experiment two.

Feeds and Feeding

Goats were fed on 500g concentrate (16% crude protein) in the morning and evening before milking time. The concentrate was made with maize bran, sunflower cake, mineral premix and salt. A mixture of chopped hay, sprinkled with molasses and salt solution was fed to all goats at 10-20% refusal rate after each milking and at 11:30 and 14:30 hours. Hay mixture was composed of garant grass, Dengu pori, Nsaam grasses and crop residues of chick peas and bean pods. Metabolisable energy (MJ/kg) for garant grass was 4.8, 8.9 for chick pea pods, 7.6 for Dengu pori, 8.0 for Nsaam and 6.4 for Bean pods. Calcium in the hay grasses was between 1.1-1.6g/kg and phosphorus between 3.2-4.4 g/kg.

Goat management

Goats were put on experiment 1 and 2, one month and one week after kidding respectively. Goats were fed under confinement and managed in the same way in both experiments. Though labor demanding, in door feeding is successful in management of breeding stock, disease control and integration of livestock into whole farm and in protecting natural resources (Shirima 2005). In door feeding particularly useful in nutrition experiments where feed intake is measured. All husbandry practices were carried out on all goats. Goats were milked at 08:00 and 17:00 daily.

Records and sampling

Daily milk output and daily feed intake for concentrate and hay were recorded for does and kids in both experiments. Other records include weekly weights for kids, monthly weights for does, and every two weeks, milk samples.

Feed ingredients samples of concentrate, hay and milk were collected for laboratory analysis. Two samples were pulled at each sampling period for all feed samples. Milk samples were from mixed milk after milking. 200ml of milk were put in bottles with one tablet of potassium and stored in a deep freezer.

Laboratory analysis

Milk samples were analyzed for total solids, protein and butter fat. Total solids and crude protein was analyzed using proximate analysis and milk butter using Geber method.

Feed samples were weighed and dried at 70^0c for 48hours. After drying and cooling, feed samples were ground to pass 1mm sieve. G round feed samples were analyzed for dry matter, crude protein and ash according to Association of Official Analytical Chemists (AOAC 2000; Mertens 2002) while a Neutral detergent fibre (NDF) was by Mertens

method (Mertens 2002) where heat stable alpha amylase and sodium sulphate were added during extraction. Acid detergent fibre was determined by method 973.18 of AOAC (1990), and sulphuric-solubilized lignin by procedures of Robertson and (Van Soest 1982). Extractions were done using ANKOM220 Fibre Analyzer using F57 filter bags of 25µm porosity (ANKOM Technology 05/03, Macedon, NY, USA).

In vitro digestibility was analyzed by Tilley and Terry procedures (1963). Feed sampled were analyzed in triplicates. Metabolisable energy was predicted by digestible organic matter per kg dry matter of feed samples. Digestible organic matter was calculated as ME /MJ/kg DM) = 0.016 DOMD according to Mc Donald (2002).

Calcium and phosphorus in feed samples were determined by atomic absorption spectrophotometer (UNICAM 919 spectrophotometer) according to (Okalebo et al. 1993). Feed samples for mineral content determination were first digesting in HNO_3/ $HClO_4$.

Statistical analysis

Data were analyzed for analysis of variance using General linear model for balanced data in 2008 and unbalanced data for 2009 in Minitab 16(MINITAB 2003). A simple analysis of variance was used with treatment effect only in the model for 2009 because of the numbers of goats. The experiment was conducted in 2008 using 18 lactating goats fed groups of 2 and repeated in 2009 with 12 animals but individually fed. Results on both 2008 and 2009 are presented in this paper.

RESULTS:

Milk output and composition and Kid growth rates

Farmer's available milk, milk composition, kid growth rates and feed intake of kids and does are presented in table 1:-

Table 1: Milk output, kid growth rate and milk composition for different suckling regimes for Norwegian dairy goats

Parameter	N	Twice milking one teat	Once milking both teats	Twice milking both teat	S.E.M	P-Value	Level of significance
Experiment 1:							
Feed intake							
Dam Hay intake in g/day for two goats	9	3678^{a}	3438^{b}	3449^{b}	67.94	0.080	S
Kid Hay intake g/day for kids of two does	9	346^{a}	329^{a}	358^{a}	19.89	0.603	ns
Milk output in 56 days ml/day	18	867^{b}	731^{b}	1083^{a}	61.33	0.003	S
Farmers milk in 56 days ml/day	18	867_{a}	731_{a}	388^{b}	60.97	0.000	S
Milk composition, %							
BF	18	4.1^{a}	4.0^{a}	5.1^{b}	0.23	0.005	S
CP	18	3.5^{a}	3.6^{a}	$3,8^{a}$	0.15	0.318	ns
DM	18	11.80^{a}	11.9^{a}	13.5^{b}	0.30	0.002	S
Kid growth rate in g/day at 56 days	18	73^{a}	66^{a}	62^{a}	7.22	0.586	ns

Parameter	N	Twice milking one teat	Once milking both teats	Twice milking both teat	S.E.M	P-Value	Level of significance
Experiment 2:							
Feed intake							
Dam Hay intake in g/day for each goat	12	2845[a]	2866[a]	2880[a]	58.03	0.893	ns
Daily hay intake for kids (g/day)	12	140[a]	69[a]	139[a]	20.47	0.140	ns
Milk output in ml/day for each goats	12	875[a]	981[a]	851[a]	79.83	0.475	ns
Farmer Milk ml/day	12	875a	981a	351b	91.21	0.000	S
Milk composition, %							
BF	12	3.3[a]	5.2[b]	4.5[b]	0.34	0.002	S
CP	12	3.1[a]	3.6[a]	3.2[a]	0.19	0.101	ns
DM	12	11.7[a]	13.5[b]	12.9[a]	0.47	0.028	S
Dam start weight (kg)		37	39	37	2.28	0.811	ns
Dam end weight (kg)		40	40	35	2.13	0.254	ns
Kid growth rate in g/day at 56 days	12	53[a]	38[a]	51[a]	8.45	0.389	ns

Farmers milk= Milk produced by a goat less milk artificially suckled to kid
Different superscript denote significant differences
BF= Milk butter fat
Milk output= Milk output at milking for each of the suckling regimes
S= Significant
S.E= Standard error of leastsquare mean
DM= Milk total solids
ns= Not significant
CP= Crude protein

Overall, 19% kid mortality was recorded on the experiment with 3 kids dying on once a day milking for twin litters, and 1 for bottle feeding.

A contrast of milk butter fat for different milking frequencies and method of kid suckling are presented in Table 2 below:-

Table 2: Variation in Least square means of butter fat percent for different milking frequency, method of kid suckling in 2009

Variable	Levels	N	Milk Fat %	S.E.M	P-value	Significance
Frequency of milking per day	Once Milking	4	5.171a	0.3919	0.008	S
	Twice Milking	8	3.743b	0.3150		
Method of feeding kid	Dam Suckling	8	4.220a	0.3592	0.694	NS
	Not suckled by dam	4	4.440a	0.5874		

Table 3: Estimated farmer's daily income from sales of fresh milk using different milking and suckling regimes

Milking Regimes	Daily milk(milliliters)	Cost of Fresh milk at 800Tzs/ litre
One teat, twice milking	875	700.00
Two teat, once milking	981	784.72
Two teat, twice milking	350	280.00
Daily losses against once milking		
One teat , twice milking		84.72
Two teat, twice milking		504.72

DISCUSSION

Milk output

Dam kid rearing methods that allow for one teat milking for twice milking and once a day milking gave higher milk output than artificial kid rearing. Milk output was similar for all suckling regimes in experiment 2 while it was significantly different in experiment 1. Experiment 1 had used more goats and therefore could bring out the differences in suckling and milking regimes on milk output. Milk output was higher for dams not suckling(P=001) and reduced by 32% in once milking and kid suckling

whole day and 20% in on teat milking and one teat suckling twice a day. Twice milking and artificial suckling of kids gave more milk and would benefit farmers where kids are fed on milk replacers. In this study kids on artificial suckling were fed own dam's milk at 300ml/milking time. Therefore milk available for farmers use was significantly lower for twice milking and artificially suckled kids in both experiment one and two at (P=0.000). In this study, artificial feeding of kids gave 86% lower milk compared to once milking and dam suckling; and 122% compared to one teat milking and one teat suckling twice a day in experiment 1. Similar results were obtained in experiment 2, 180% milk losses with twice milking and artificial kid rearing as compared to once a day milking with kid suckling whole day and 149% compared to one teat milking and one teat suckling. Our findings agree with (Diken et al. 2008) when working with goats. Kid suckling effect appear to explain the higher level of farmers available milk due to high levels of oxytocin which are produce with kid suckling effect (BarPeled et al. 1995; Marnet et al. 1999). Secondly, galactopoietics hormones at suckling increases milk secretion compared to two exclusive milkings per day. Thirdly, mother-young contact appears to explain the higher milk yields than none dam contact (Hernandez et al. 2007), where cows suckling gave short term increase in milk output than machine milking in cows. Long term results of suckling include enhanced mammary development, increase mammary proliferation and differentiation of mammary cells of goats (Wilde et al. 1987) and in cows (Hale et al. 2003; Hillerton et al. 1990). Fourthly, the presence of the kid influences milk let down (Hernandez et al. 2007), mother young contact gave more milk than in one contact. The presence and absence of the kid for suckling does

appears to result in higher production of hormones oxytocin. Suckling induces high production of oxytocin in lactating animals (Ramos et al. 2008), and calf suckling increased oxytocin than exclusive milking for Gir cows (Negrao 2008). Fifthly, the size of gland cistern also explain the similarities in milk output and available farmers milk for dam suckling kids either with one teat milking twice a day or two teats milking once a day. Goat have larger gland cistern (80-90%) of udder milk (Peaker & Blatchford 1988). This study has shown a milk reduction of 32% for once a day - milking and suckling whole day and 20% for one teat milking and one teat suckling twice a day compared to twice milking two teats and not suckling in experiment one. Similar results with 26-36% reduction in milk output (Boutinaud et al. 2004); (Salama et al. 2003), were reported for Saanen, and 15-26% in cows milked once a day (Pomies et al. 2008). A reduction of 18% was also reported for Alpine goats milked one a day (Komara & Marnet 2009) for goat in late lactation). The similarities in milk output observed in experiment 2 could be explained by the larger gland cistern size for goats (Peaker & Blatchford 1988) and that the average production of one teat could provide comparable amount of milk of 600ml to feed a kid per day as used in this experiment. The results agree with findings by Komara (2009) and (Delgado-Pertinez et al. 2009) while working with Alpines.

Kid growth

This study has shown that kid growth rate was not significantly different for different suckling regimes in 2008 and 2009. Kid growth rate were similar because all kids fed on dam's milk. The results agree with (Diken et al. 2008) reported similar results for Saanen kids suckled full udder and suckling left lob of the udder. Similarly, Knight et al., (1995) reported that's lambs could be effectively reared with restricted access to ewes. In this study all goat kids fed on own dam milk by suckling or bottle feeding soon after milking. Different results are reported where goat kids are fed milk replacers because of the lower digestibility of milk replacers as compared to goat milk (Sanz Sampelayo et al. 1990) and lack of growth promoters present in dam's milk (Baumrucker & Blum 1993). Kid growth rate found in our study are higher than those reported by Mtenga et al., (1992). The differences could be explained by differences in management of the goats.

Kid growth rate was similar also because kids fed on more less similar amounts of dam's milk. Daily milk output from one teat twice milking and once milked two teats indicate that one teat could provide enough milk comparable to 300ml to one and almost sufficient for twins. Milk output from twice milking plus 600mls fed to kid or 1200ml for twins indicate that the afternoon milk was likely to provide enough milk to the kids being suckled the dam whole day. Kid suckling does appear to produce more milk as compared to does not suckling (Hernandez et al. 2007). Farmers practicing once milking of two teats and dam suckling and one teat suckling are

driven with farmer's traditional knowledge of maternal instinct of milking goats to keep milk for their kids. Traditional knowledge agrees with physiological work which showed that mother –offspring bond and maternal behavior inhibited oxytocin release but not affecting prolactin and cortisol in goats (Hernandez et al. 2007) and in ewes (Marnet & Negrao 2000). Milk withheld by the dam is then released when suckling own kid.

Farmer's idea of suckling the kids seems to offer similar kid growth rate and is attractive for smallholder farmers. Dam kid suckling is labor savings and does not subject farmers to worries of needed hygiene in kid bucket or bottle feeding. Dam-suckled kids take in warm milk while artificially suckled kid depends on farmer's timing and hygiene to take in quality milk. Artificial kid suckling requires more time and adequate hygiene to reduce infections to the kids and ensure that kids suckle warm milk. Feeding goat kids artificially can be time consuming and not easily attainable under small holder conditions

Milk composition

Milk protein was not significantly different for different milking and kid suckling regimes in experiment 1 and significant in Experiment 2. Milk samples in experiment one were not preserved while experiment 2 samples were preserved. Results of experiment 1 agree with Komara et al., (2009) for Alpine dairy goats and (Delgado-Pertinez et al. 2009) for Payoya autochthonous dairy goats when comparing natural and artificial rearing of kids in the first 5weeks. In experiment 2, a 10% reduction in

milk butter fat with twice-milking as compared to once a day milking and suckling whole day was also reported by Knight et al., 1995 when working with ewes. Milk protein was significantly different for milking and suckling regimes in both experiment one and two. Milk butter fat results observed in this study indicate similarities for suckling goats and significantly higher amounts for twice milking and artificially suckling goats in experiment 1. Experiment 1 one teat milking and one teat suckling gave lower buttermilk butter fat than once a day milking (58%) and twice a day milking without suckling (33%). In experiment 2 once a day milking gave higher milk butter fat and protein. A contrast for milking frequency has shown once aday milking increased milk butter fat by 45% (5.17 vs 3.74%). Similarly, once a day milking reduced milk yields but increased milk crude protein and milk butter fat in cows (Pomies et al. 2008) and (Capote et al. 2008; Salama et al. 2003); in goats. Higher milk butter fat could be due to positive correlation of lipolysis and milking frequency (Wiktorsson et al. 2000). Milk butter fat as other fats is synthesized by de novo fat synthesis. Fat synthesis is regulated by peptide hormone, glucagon and insulin. Excess energy stimulates insulin production which indicates the need for fat synthesis and glucagon works vice versa. Higher insulin was observed in cows that had a reduced milking frequency in cows (McNamara et al. 2008).Therefore the higher milk butter fat in once milked dams could be explained by the increase in insulin.

Conclusion

Norwegian goats reared in tropics can be managed using traditional methods of once milking and one teat milking and one teat suckling and can provide higher amount of farmers milk and comparable kid growth to twice milking and artificial suckling. Firstly, excess milk of three quarter a litre per day provided by one teat milking and one teat suckling method and once a day milking is of greater benefit to household members or community, especially now when goat milk is of vital role in human nutrition. Secondly, once milking method is labor saving. Once a day milking is ideal for farmers in crop-livestock production systems because it is labor saving. Once milking regime would save farmers time for milking which can be allocate to other labor demanding activities on the farm; and also kids would be reared by the dam. When practicing once a day milking and one teat milking and one teat suckling, farmers need milk less when does have twins to reduce kid mortalities. Twice milking and artificial suckling would be useful where consumer prefer low butter fat milk and in commercial farms where kids are fed on cheaper milk replacers. Artificial suckling would a challenge under smallholder farmer's condition because it requires prompt feeding and hygiene of milk handling.

Thirdly, once a day milking offers extra butter fat and total solids percent which is of greater value in milk processing. Higher total solids and butter fat obtained with once milking does not compromise farmer's available milk and kid growth. Moreover, once day milking provides extra daily income from sales of fresh milk (504; 84 Tzs) compared to twice milking and one teat milking. Traditional kid rearing methods

could be recommended to farmers rearing Norwegian goats in Tanzania and in the tropics.

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Paper V

Social Value of milking local goat on Likoma Island in Malawi: implications for livestock interventions

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Abstract

This article focuses on the practice of milking local goats on Likoma Island in Malawi. We show that the social value of goat milk is embedded in the local 'tea culture' in Likoma. Referring to the local history of the tea culture, we present and analyse current practices of milking local goats, and show how goat milking found its niche in a cultural context where the tea culture expresses both local identity and social motivation. Tea is served in daily meals, during festivals and in times of food shortage. Goat milk in tea enhances both the social – and nutritional – value of the tea and the cultural values within the community. Goat milk is further preferred by poor households due to economic, as well as environmental conditions which make goat rearing suitable, as goats can survive on tree leaves in the dry season. The geographic position of the island and lack of milk storage facilities make goat milking ideal for supplying small quantities of fresh milk for daily household use. Milk goat rearing also offers protection for poorer households against uncertain fishing, in addition to small business incomes used to purchase food. Goats are acquired through farmer to farmer goat loans. Goat lending and borrowing contribute to social cohesion of the community through social capital building and farmer information exchange. Thus goat rearing enhances social networks which are glued by trust and maintained through common interests among local people.

Background

Rural populations constitute 85% of human population in Malawi, and depend mainly on agriculture for livelihood (NSO 2007). Maize is the staple food, while other food crops produced in large quantities include potatoes, rice, cassava and pulses. Cash crops include tobacco, tea, coffee, cotton, sugarcanes and paprika. Sixty-five percent of rural households own livestock, such as cattle, goats, sheep, pigs and poultry. Goat populations show an increase per capita over the past 10 year (ASWAP 2010). Twenty four percent of those keeping livestock own goats and 50% own chickens, while only 6% own cattle, and 9% own pigs. Distribution of goats by Agricultural Development Division (ADD), indicate the lowest numbers in Karonga ADD, followed by Salima ADD and Mzuzu ADD (Kadohira et al. 2006). Likoma district, which is the focus of this article, falls under Karonga ADD. In Malawi as a whole, fifty-six percent of households cultivate less than 1 ha (Banda 2008), with 40% living below poverty lines in 2007(ASWAP 2010). Due to increase in human population, open land which was not suitable for crop production and earlier used for grazing is now cultivated and thus unavailable for livestock feeding. Goats however, do not require much space; they do not compete with man for use of grain as feed but utilize small quantities of crop residues, grass and browse, unlike big animals such as cattle. Goats also fetch more cash as compared to chicken if an animal is sold. As such, goats are used as a 'bank on hoof' by poor households and as a 'nutrients stove' which uses feed not suitable for man to produce valuable products like milk and meat. Goat milking has also for a long time been practiced in communities along Lake Malawi, such as Usisya in Nkhatabay and on Likoma Island. People in these communities milk local goats. Milking local goats is actually known to be a tradition at Likoma Island.

Various livestock species have been introduced to better the lives of rural farmers. Dairy goats are being promoted in Malawi and many African countries to stimulate goat milk utilization, through the UDLP[1]

[1] UDLP: Universities Development Linkage Project

project in Malawi (UDLP 1997) and the PANTIL[2] project in Tanzania. In particular, goat milk is being promoted for the rural poor households who cannot afford a cow, with a slogan of 'a poor man's cow'. Different dairy goat breeds were introduced in Malawi through Bunda College of Agriculture, the research station in Salima and some non- governmental organizations like SSLP[3] and some Churches[4] . Since 1970's dairy goat improvement programmes imported *Damascus*[5] and *Anglo Nubians*[6] and *Saanen*[7] from South Africa. Challenges with on-station experiments at Bunda College as regards survival of goats led to introduction of Saanen in particular, to farmers around Bunda College. Farmers were trained in goat management and utilization of goat milk as weaning food for malnourished under-five children. Farmers milked the goats during the period of project implementation. After the project implementation period, less and less farmers milked the goats, but benefitted from sales of crossbred goat kids which fetch twice the price of local goats. Like in many projects, after the implementation period, continuity depends on the ability of the project innovation to fit into social values and household needs. In this article we will show how livestock-keeping practices are closely linked to both socio-economic and cultural factors.

Several studies have been carried out to compare goat milk to cow's milk regarding nutritional value. Nutritional attributes of goat milk compared to cow's milk include: It is 4-5times higher in oligosaccharides[8] (Martinez-Ferez et al. 2006). Goat milk is 20-40 fold high in taurine[9] (Mehaila & M.A. 1992), which is used in bile salt formation, calcium transport, antioxidation, in the central nervous system and in osmoregulation (Redmond et al. 1998). Goat milk is 62% higher in linoleic acid[10](CLA) than

[2] PANTIL: Programme for Agricultural and Natural Resources Transformation for Improved Livelihood from 2005
[3] SSLPP:Small Scale Livestock Promotion Programme importations of Saanen goats
[4] The Baptist church brought in AngloNumbian goats
[5] Damascus is a dairy goat breed
[6] Anglo Nubians is a dairy goat breed
[7] Saanen is a dairy goat breed from South Africa
[8] Oligosaccharide is a sugar of two molecules, a carbohydrate
[9] Taurine is an amino acid, a protein unit
[10] Linoleic acid is a type of fatty acid

cow's milk. CLA has also anticarcinogenic[11] effect (Mc Guire & Mc Guire 1999). Goat milk further contains higher content in mg/100g milk for Ca, P, K, Mg and Cl, but lower for Na and Sulphur than cow's milk (Park 2006). Goat milk can also be essential in infant formulas (Bouckernooghe et al. 2006). Goat milk has a complex array of Nucleotides[12] (NU) (Prosser et al. 2008). Nucleotides facilitate immune system maturation of off-spring fed on milk; hence NU is part of infant formulas (Schallera et al. 2007), 2007). Prossser showed that infant formulas from goat milk had same levels of NU as human milk and do not need additional NU (Prosser et al. 2008). On the other hand, goat is deficient in folic acid, and its use in weaning food requires supplementation of folic acid.

The basic motive behind dairy goat interventions is the nutritional attributes of goat milk, which make it suitable as livestock specie for poor households, not only for income but also to combat child malnutrition and address HIV/AIDS challenges. HIV/AIDS prevalence rate for Malawi is reported to be at 12% (ASWAP 2010). Use of dairy goats in livestock interventions in the sub-Saharan Africa and Malawi where few or no alternative infant formulas exist for HIV-positive mothers in poor rural households is an option. HIV/AIDS mothers are advised to exclusively breast feed in the first 6 months because the period has a lower risk for transmission of the virus to the child (UNICEF et al. 2003). After six months, mothers are advised to stop breast feeding and use affordable, acceptable, available, safe and sustainable milk replacements. Here goat milk can be a valuable option.

Aims and objectives of the study

The study reported in this article more generally aims at addressing the challenges of uptake of dairy goat interventions by rural poor smallholder farmers, its central element being related to goat milk utilization.

[11] Anticarcinogenic: a component that counteract formation of cancer cells.
[12] Nucleotide : molecules which when joined together make structural material of RNA and DNA

Challenges in the sustainability of dairy goat interventions became a motivation to think outside the framework of livestock production and use an anthropological approach. The study focused on the Likoma community in Lake Malawi, which has a tradition of milking local goats. Learning from the tradition of milking local goats in Likoma could allow livestock researchers to identify the reasons why rearing milk goats found a niche within Likoma community, and drawing lessons from this case could inform development initiatives of dairy goat introduction to poor rural farmers in Malawi and elsewhere. Could such findings become an eye opener in addressing challenges of adoption of technologies that aim at improving productivity and livelihood? Could learning from existing goat milk rearing systems be salt to the tasteless good technologies being introduced in good faith, with lots of passion to improve the living standards of smallholder farmers?

Study Area

Likoma Island, in Lake Malawi, lies on 12^{o} 04'S 34^{0} 44'E, occupying 18 km^2. With a population of 9,000 people, it has a population density of 500/km^2 (Map in appendix I figure1 &2). Likoma in Chichewa means 'beautiful' or 'desirable' place (Tengatenga 2010):79). The island was first locally discovered by fisher men who had lost their way on the lake. The fishermen referred to it as a nice place because they discovered it had no wild animals, as the main land. The fishermen's only fear was of being caught by crocodiles when they were by the lake side in the evening or when it was very quiet. Hence, according to local history, they called the place Likoma. Later the island was occupied by more people from the mainland, mainly from Nkhotakota and Nkhatabay in Malawi, and also from present- day Mozambique. During British colonization, the Island was discovered by a Scottish missionary, Elton, in 1877 (Tengatenga 2010):79). Tengatenga also reports that in 1885, the Island was the home of 2,600 'nyasas', an 'industrious race' occupied with fishing and net making. As the land was barren it only had few sheep

and cattle surviving on shrub and bushes. The Scottish Missonaries made Likoma a base for UMCA[13] Anglican Mission to Nyasa (now Malawi) and the large Cathedral of St Peter was built here in 1903. The Island is at present an exclave of Malawi, surrounded by Mozambican territorial waters, but belonging to the Republic of Malawi. As the largest inhabited Island on Lake Malawi, Likoma Island is one of the two islands that make up Likoma District, which also include Chisumulu Island.

The community depended mainly on fishing and sales of fish to the mainland. But fish catches have declined over the years, and they are gradually shifting to depending more on non-fish businesses.

Still income from fishing is obtained through sales of both fresh fish and dry fish. Some rent fishing gear and work for those who own it. The staple food on the island used to be mainly cassava, until this crop was hit by 'mealy bug' disease in the 1980's. Currently, very few grow cassava on the island, but some islanders cultivate it in Mozambique, where they access land through intermarriages. The community now grows other crops like maize and rice, cowpeas and pumpkins in small quantities. Eighty-eight percent of households on Likoma Island own livestock of which 41% of keep goats, 2% cattle, 3% sheep and 73% chicken (NSO 2007). Firewood and vegetables for local consumption are brought in by boats from Mozambique, while groceries, clothes and other commodities are brought by a steamer (called *Illala)* from the main land twice a week. Staying at Likoma for some time, one easily observes that stocks which run out in shops, restaurants and drinking places are replenished when *Illala* comes to the island every Wednesday and Saturday.

Research Methodology

Setting out to identify social conditions and cultural norms and values that could help us understand the local practices of milking local goats in Likoma, a field study was scheduled including several visits from

[13] UMCA: Universities Mission to Central Africa

April 2009 until April 2010[14]. Phase one was conducted in April 2009 to May 2009 when a series of focus group discussions (Bryman 2008):474) were carried out in Likoma town, and in Chiponde, Chinyanya, Madimba, and Chiwoko villages with local development consultative committees[15]. These villages were chosen both for accessibility and concentration of households milking local goats. The focus group discussions were carried out with the development consultative group of each village, as they were usually aware of development initiatives in their village and had representatives of different development initiatives committees operating in the Likoma community. The committee is recognized within the district development administrative structure, and also by the Agricultural Office at Likoma. The meetings were scheduled for the afternoons at 2 p.m., when community members have usually finished fishing and fish-related tasks and other household commitments. The discussions were taking place at the *bwalo la mfumu* (village meeting place) in each village. Each village has an open space under a tree, close to or within walking distance to the chief's residence, where people have village meetings when summoned by the chief. The questions discussed included livelihood strategies, livestock production, goat production, the milking of local goats and its history, acquisition of goats, challenges with goat rearing, and goat milk utilization. The issues and views presented in discussion groups were noted down in a notepad and summarized each evening.

Focusing more specially on the practice of milking local goats, in-depth interviews were conducted with a sample of key informants (Bryman 2008):409). Key informants for interviews on for the practices of milking local goats were identified using snowball sampling (Bryman 2008):184). Snow ball sampling allowed each identified respondent to propose the next who could have more information or specific information regarding the practice of milking local goats. Milking of local goats on Likoma Island is not done in all households; therefore, detailed information on the topic could only be traced from households

[14] The study was carried out in three phases by the first author supported by Bunda Capacity Building (BCP) and Agricultural Research and Development Programme (ARDEP) funding.
[15] See Figure 2 in Appendix I for Map of Likoma and villages covered by the study.

milking local goats. As such key informants were easily identified and some informants provided more than one name which allowed for flexibility when one was not available or required rescheduling the date of the interview. Informants included elderly women (8) and men (2), old business men (1), a retired Anglican priest (1), men who once worked with missionaries (1), male and female chiefs milking local goats (2) and an acting District Commissioner (1) at Likoma Island. The informants were interviewed in their households and their responses were recorded in a note book during the interview. A total of sixteen people were interviewed as key informants using snowball sampling. The interview guide covered the history of milking local goats, origin of the goats, utilization of goat milk, importance of goat milk in Likoma community, reasons for milking goats, who taught whom and challenges in goat rearing. A booklet by Chrispin Chindongo [16]available at one of the Chief's houses was used to get additional information on the history of Likoma. After obtaining information on the practice of milking local goats, a series of household interviews were scheduled.

Household interviews were conducted with 40 households milking and 40 not milking local goats. The households were sampled from a list of households milking and not milking goats. Since the number of milking households was relatively few, the households milking and not milking local goats were drawn as a purposive sample to represent both female headed and male headed households. The households were identified using a village household list made with assistance from the Agricultural Office in Likoma. In each household, one representative was interviewed, and the interview took place in their homes between 10 am and 3 pm while appointments were made a day before the interview, and rescheduled when need be. The time of interviews was set to allow for respondents' involvement in fishing and fish related activities and other household commitments, as men usually left the households to prepare for night fishing late in the afternoon. Nevertheless, most of the respondents were women, since few men were available after all. Semi-structured interviews (Bryman 2008):438) with a questionnaire were used. The questionnaire was structured for demographic information on the household, and unstructured for income

[16] Chrispin Chindongo: Authored a small booklet on the history of Likoma in 1970's, now kept by family members.

sources, assets, acquisition of goat flocks, borrowing patterns and relationships of those involved in goat loans. Together this information would provide characteristics of households milking and not milking local goats, and give information on patterns of social networks in acquisition of milking goats on the Island. Forty goat farmers not milking and forty milking local goats were interviewed in Chiponde, Madimba, Chiwoko and Chinyanya villages.

The methodological assumption in the use of focus group discussions was that the different individuals in the group together are able to present patterns of practices in the community, as well as a broader and general picture of the knowledge and preferences of the group representatives. More detailed information was obtained through snow ball sampling of key informants to explore the practice of milking local goats. As snow ball sampling tends to include only those within a connected social network (Gibert 1995), in this study emphasis was put on ensuring that key informants were of various backgrounds and positions in society. Therefore, the views and local knowledge gathered are assumed to be representative of Likoma community as regards rearing goats and utilizing goat milk. In addition, general and specific information about households milking and not-milking in relation to income and livelihood was obtained through the household interviews. In the questionnaire the questions were specific, especially on quantifiable data, but respondents do not keep records of income and income sources. Thus they had to estimate e.g. average earnings from various activities during the interview, and income values obtained in this study are estimates made by farmers. But since the study had equal representation of households milking and not-milking, we assume this should not affect the comparison of these two groups. The practice of milking local goats, as passed on from generation to generation in Likoma, is at present being challenged by changing preferences and values. The interviews made it possible to see that households milking and not milking local goats have different means of survival, as well as different assets. The detailed interviews of households milking and not- milking local goats also served to reflect social status and networks operating in goat acquisition.

Qualitative data from key informants and focus group discussions was summaries according to themes and interpreted. Quantitative data from households milking and not milking was analyzed using SPSS to drive frequencies and compare means.

Results

Likoma

Likoma Island has twelve villages, four of which are Chinyanya, Chiwoko, Chiponde and Madimba where this study was carried out. The main occupations for the eighty households (hh) interviewed are fishing (26%), farming (20%), business (16%), working as a teacher (15%), and casual laborer (13%). Among the respondents 88% are Anglican Christians (91% milking hh and 83% not-milking hh). Fifty-eight percent of the respondents were married (59% of milking hh and 56% of not-milking hh). In the non-milking hh, 70% had upper primary and junior education as the highest education attained, while milking hh 52% had upper primary and junior education. The milking group also had 36% respondents with lower primary as highest education attained, while this was this case for only 11% of hh not milking. We chere see that the milking hh had a lower education status than the non-milking hh.

Cassava is the main staple food at Likoma and average yields were significantly (P=0.018) higher for households not-milking (714kg) than milking hh (253kg). Although the mealy bug disease eliminated cassava crop in the 1980's, cassava is to some extent still grown at Likoma. In households interviewed cassava is a staple food. Maize is also grown and average yields of 175-250kg[17] were harvested by both milking and not-milking group. The average cropping field is less than 0.01ha and low yields make households food insecure before the next cropping season. The community survives by purchasing food from the mainland, and some also by cultivating cassava in Mozambique through intermarriages. One farmer expressed it this way:

[17] The study was done after a cropping season when many households benefitted from a maize input subsidy from the government and most of the households had cultivated maize.

We also survive by cultivating cassava on some land we own in Mozambique across the Island. There is a lot of intermarriages of Likoma and Mozambique people. My wife is from Mozambique, we have cassava fields in Mozambique, and we schedule visits to cultivate and harvest the cassava.

Fishing is the major source of income on Likoma Island. The 26% in our sample of hh earns income through sales of both fresh and dry fish, and from fishing related activities. Income from sales of fresh fish was not significantly different for households milking and not milking. Income from sales of dry fish was significantly (P=0.013) higher for households milking (17,772.00± 34,107 Malawi Kwacha (MKW[18])) than not milking (7,694.00± 15, 643 MKW). The milking group had significantly (P=0.007) less income from renting out fishing gear (272.00 versus 2,500.00MKW). The milking group also had more income from work as casual laborers (26,640.00 versus 14,450.00MKW). Assets owned in somewhat higher numbers by milking than not-milking groups include *Zilepa (14 versus 12)*, radios (38 versus 25), Televisions (6 versus 3) and mobile phones (32 versus 25). The milking households had more of the locally made fishing nets, and ensured to access information and connected through mobile phones probably because they were also engaged in small fish businesses and required to be easily reached. The community generally, engages in income generating activities like small business of household supplies, and survive also on remittances, but here there were no differences between milking and not-milking group. Fish catches have deceased over the years. Small catches and up-wailing winds on the lake which makes fishing impossible between June and August are both making life to come to stand- still on the island. The community then survives on income reserves and by non-fishing activities such as small businesses and sales of goats. Goats also offer alternative stand-by capital in case of losses in business of selling dry fish.

The average flock size of mature goats in milking hh was four, and three in not-milking hh. There were no differences in numbers of goats consumed or sold in milking and not-milking households. The milking hh sold and also consumed one goat per year, while the not milking hh consumed one goat but sold two

[18] Exchange rate as of June 2011, 140Malawi Kwacha = 1 US Dollar

goats per year. Goats are reared on Likoma because of their ability to utilize trees as feed in times of feed shortage. The major limitation to keeping big ruminants is shortage of feed which worsen in the dry season. Raising big ruminants is a challenge because of the small land and scant vegetation cover on the island. Goats survive by feeding on plant leaves which are fetched by goat owners. Ninety-six percent of household keeping goats supplemented them with leaves from trees. Goat farmers seldom milk suckling does in the dry season because goats are kidding in the rainy season, and also due to less feed. The dry season is the time when the community struggles to feed goats and the goats survive by feeding on tree leaves like *Sakazinje*[19], Mt*athanyerere*[20] and *Msambamfumu*[21]. The challenge of the dry season is so huge that some animals abort or die if the farmer does not make an effort to fetch leaves for feed. Several farmers described the period as 'the time when the goats herd the farmer and not the goats being herded' in Chichewa *mbuzi zimakuweta nthawi yoti dyera lasow*. The Chichewa word *dyera,* in Likoma, means 'tree leaves supplement for goats'. Several informants gave the following statement to describe feed shortage in Likoma:

Feed is very scarce in the dry season. Goats survive on this Island because they feed on tree leaves which we have to fetch for them. Some goats die on tethering sport if owners don't fetch tree leaves called 'dyera' in Likoma language. Goat rear the owner through torment to fetch feed which a translation of a Chichewa phrase ' mbuzi zimakuweta'.

Goats are not housed at night, but rather tethered on a peg outside the house the whole year, while few farmers construct temporary structures to protect their goats from the rain. Kids are housed in the farmers' house until they are clever enough to stay with the dam outside the house. The doe which are milked are tethered away from the kid, to ensure that they do not suckle at night. When goats are milked in the rainy season, they give small quantities, like 150ml of goat milk on an average, and this suffice for serving 6 cups of tea with milk. Where goat milk is preferred, it is because of its heavier consistency in tea as

[19] One of the trees which has lots of leaves in dry season and edible by goats
[20] Small-fruited potato bush, *Phyllanthus guineensis*
[21] Pod Mahogany, *Afzelia quanzensis*

compared to powdered milk from cow's milk. Goat milk makes their tea heavier or thicker as compared to use of similar quantities of fresh cow's milk. Where a family cannot afford to rear their own goat, they usually buy 300ml, a coca cola bottle, of goat milk from goat farmers at 40MKW. This is considered sufficient for a family's daily tea requirements, and preferred to spending 50MKW sachet of powdered milk which is not sufficient. It is difficult to store fresh milk due to rationing of electricity, and milking or buying small quantities for daily use seem to be a rational adaptation. One goat keeper compared goat milk to cow's milk in the following way:

I like goat milk because it is easy to keep. After morning milking, I strain and boil the milk. If I plan to take my tea with milk later in the day, I can just cover the boiled milk and it keeps well till the afternoon, but if we boil fresh cow's milk it goes bad easily.

After milking the doe, they let the kid stay with the doe the whole day. Milking is done once a day from when the kid is 2 weeks old until when kid horns start to come out. When they are differentiating goat milk from other milk they would call it '*likama,*' Chichewa for 'just milked'. Soon after milking, the milk is usually strained and boiled or sold. The boiled milk is kept in a cool place in the kitchen, and can stay a whole day without going bad. Goat keeper's not-milking prioritized kid growth. Seventy-seven percent of those not-milking said they aimed at fast growing and healthy kids. On the other hand, the milking hh said they milked the goats because they preferred goat milk for its heavier consistency (60%) and flavor (95%). One local informant explained:

The milk we buy in small sachet of 50 MKW is not enough for my tea pot. But if I use a few milliliters of goat milk, the tea has enough milk. Goat milk is of a heavier consistency, therefore a small quantity of milk is sufficient for use with my small tea pot. Tea with goat milk is of a heavier consistency than cow's milk or powdered milk of the same quantity.

Historical background for local practices

When the Universities Mission to Central Africa (UMCA) established Anglican Mission on Likoma, the Anglican missionaries employed local people as labourers, working as cooks, house servants and with various tasks at the church. The workers saw the missionaries drinking tea with milk. One of those who had worked with Missionaries explained in the following way:

Most of us worked as cooks and house boys for Anglican missionaries at the Mission. We saw the white people taking tea as we worked for them. Slowly we started taking tea also in our homes. We also learned to use soap in washing clothes when instructed to do washing in our day to day tasks as houseboys for the white men, the missionaries.

Before colonial times, Likoma Island was a small port in Lake Nyasa where sea traders could refresh food supplies on their way with goods to and from the Indian Ocean. The sailors exchanged sugar, salt and clothes for eggs, chicken and rice. The local authority persons on Likoma told:

We had a small port for sea traders passing through Lake Nyasa. Sea traders used Likoma Island as a point of refreshing their food supplies. They traded sugar, salt, clothes in exchange for eggs and chickens and rice. The sugar we got in exchange for eggs made us enjoy our tea.

This barter made the community acquire sugar for use in tea, locally called *tchayi* . Before the introduction of tea leaves, Likoma community used and still uses, its own traditional tea substances made from processed roots of the *Mkwatama*[22]tree and green leaves of *Lune* [23] trees. The trees grow naturally on Likoma Island and extra provisions are also bought from Mozambique which is only a few hours boat ride. The roots are ground and put in hot water and strained as tea leaves. This tea is also considered best when served with milk.

[22] Mkwatame:Snobby bush willow, *Combretum mossambicensis*
[23] Lune tree: : Small trees naturally occurring on Likoma, African Spider flower, *Gynandropis gynandra*

According to the sources referred to inTengatenga (2010), in 1885 there were few cattle and sheep on Likoma. As more people came to occupy the island from the mainland and Mozambique, they also brought goats. We know that the people from the mainland who came to occupy Likoma were mainly from the lake shore districts of Nkhotakota, Nkhatabay and Salima in Malawi. These lake shore communities are also commonly known to milk goats, unlike other districts of Malawi. Where the practice of milking goats originally came from and how it spread to other localities is not clear at this point.

What we know is that tea drinking became a common practice in Likoma, and is an essential part of its 'cuisine'[24]. In Likoma community, a proper breakfast is tea served with something. Tea with milk is the most preferred, but households who cannot afford milk take black tea along with available snacks. The snacks range from bread, scones, *mandasi (wheat flour fritters)*, *zitumbuwa* (maize flour fritters) or potatoes, cassava and rice. Tea can also be served at any time of the day, like mid morning or mid lunch and in between main meals. Lunch and supper are main meals, usually consisting of *nsima* or rice with a relish[25], but can be substituted with tea and a preferred snack or served with tea as starter. In times of food shortage, families survive by taking only tea. The preferred tea in all cases is tea with milk.

The milk available for purchase on the island is mostly powdered milk, which is sold in sachets, with the smallest amount enough for one cup, costing 50 MKW. Fresh milk cannot be stored because electricity from fuel generators is only available for limited hours each day. Local production of milk is limited to goat milk, primarily because of shortage of livestock feed on the Island

[24] Cuisine defined by Ohna et al., 2012:8) refers to a formal and symbolic ordering of food "through practices of selection, preparation and presentation…" In practice it may consist maize or cassava flour thich porridge served with complementary dishes of fish, meat, pulses or vegetables with a sauce along with tea for Likoma(McCann, 2009:5)

[25] Relish: a dish taken with maize or cassava meal thick porridge. Usually it can be made from fish, meats, pulses or vegetables in a sauce as a stew.

The Likoma 'tea culture'

In spite of the relative scarcity of milk, tea served with milk as a key element in the Likoma 'cuisine' also constitute what we will call a 'tea culture' on the island. **'**Culture' has been defined as a complex whole which includes knowledge, belief, art, morals, laws, customs and any other capabilities and habits acquired by man as member of a society (Tylor 1871/1974). In this context, eating can be seen as a response to both biological and cultural stimuli, which also fulfills both biological and social needs (Fieldhouse 1996):1). Culture involves a value system that labels 'bad' and 'good' food regardless of nutritional value. What people in a specific local setting can eat and drink is, of course, to a large extent determined by local resources, sources of livelihoods and by household's purchasing power. But food preferences and how food is prepared and served are conditioned by culture. Cultural patterns shape customs and practices of human food ways, such as food chosen, ways of eating, food preparation, numbers of meals per day, time for meals and size of portions eaten. Food habits are developed and maintained because they have both social and symbolic meanings in a particular culture.

On Likoma Island, the tea culture is part of Likoma people's identity. It is expressed in the welcome gesture of serving tea to a visitor. There is no better welcome gesture to somebody from Likoma than being served tea. In other places in Malawi, to slaughter a chicken signify a good welcome. On Likoma, serving tea, regardless of the time of the visit, signifies the best welcome. Several informants expressed it in the following way:

If I visit my friends and they served me tea with milk, I will always appreciate them in my life. Even if I visited them at lunch time, and they served me only tea, I will have lasting good memories of their kind gesture on that visit.

Tea with milk signifies the best welcome, and gives visitors good memories when the tea is served with milk, regardless of provision of any snack. As a signifier of being welcome it can be shared with friends as they report or recall of the visit. People on the mainland also associate the preference and importance

attached to enjoying a cup of tea with people from Likoma. The satisfaction attained after being served tea is seen as characteristic of Likoma people. A fisherman from Likoma told:

When you have an opportunity to host a visitor from Likoma, just serve them tea, even without bread they would appreciate. Even if you serve it at lunch we are very alright, and we will gladly enjoy and appreciate your hospitality.

When travelling on the mainland across the Lake from Likoma, people from Likoma know that people from the Island like tea, and easily identify home mates with reference to their preference for tea. On Likoma, having tea is a constitutive element in a decent life. One Fisherman in Chinyanya village said: 'Purchase of sugar and other things for tea remain a man's priority on the supplies list when a household is recovering from a period of food shortage'. He explained further:

As a husband I work hard to supply my household with food. If I don't get enough from fishing, and I have run out of food supplies, the first thing I buy for my household when recovering from food shortage is sugar for tea. If I can manage I buy milk. But tea is the basic for survival even if we don't have food in the house. But if I have left my family with ingredients for tea, I am not worried.

If the family was left without any food, the first thing they would buy after a day's fish sales is a packet of sugar. They believe the family can survive without taking *nsima* of cassava or maize if there is a lack of supplies, while they survive on taking tea. The same priority applies for households making their earnings from g*anyu* (payment from any labor service) and other income sources. The preference is tea served with milk. But tea with goat milk can be taken even without sugar.

A farmer in Chiponde village told that the last time the period of no maize supplies at Likoma's ADMARC lasted for a month, people survived by taking tea. He told:

We once survived on drinking tea for three weeks when we had no maize supplies at all selling points on the island. Life was hard but we got strength each day by taking tea as a substitute for proper meals.

Also when different foodstuffs are available, tea is highly appreciated. One of the informants explained it in the following way:

If I should say that I have enjoyed my meal, it has to be served along with tea. Even when serving lunch of maize porridge and chicken meat on a hot day, it is better when taking tea after the meal.

When village development meetings take place in the afternoon, tea is always served, either before or after the meeting.

Likoma tea culture is also expressed during funeral ceremonies. Funeral ceremony meals in the main land of Malawi usually include serving breakfast to bereaved family members and the mourners who have slept at the compound where a person passed away. Lunch of *nsima* and relish (usually meat, fish and vegetables) is served to all who come to the funeral either, before or after burial. Supper is served for the bereaved family after the burial, and breakfast for the bereaved family before a family discussion concerning the deceased. On Likoma, women who cook at the funeral prepare tea as a main funeral meal for all who come to the funeral. The tea is served with whole maize meal fritters, locally called *zitumbuwa,* or drop scones made with wheat flour, locally called *mandasi,* depending on income status. *Zitumbuwa* is made by everybody, while those with more income would serve *mandasi*. Everybody gets black tea and those who can afford will serve tea with milk. Tea with milk will always be served, by families who can afford it, to distinguished visitors such as village leaders and church leaders.

After the general tea has been served, men are also served tea when discussing issues of the deceased and the funeral in general, a period locally called '*makani*'.

It is commonly believed that the community of Likoma was created as a result of inter marriages between Tongas of Nkhatabay, and *Nyanja*-speaking people from mainland Malawi and Mozambique, who sought resting sites on the island when fishing on lake Malawi. The Tongas have a tradition of inviting friends from other villages for traditional dances, inviting them to their homes for meals for a couple of days throughout the dances period. Such a festival tradition is also practiced on Likoma. Each village allocates

a week-end each year when they invite and host friends for traditional dances and meals in their homes. The men's dance and dancing group is called *Nganda* in Chichewa while the women's dance is called *Chioda* in Chichewa. One informant said:

When am hosting my friend from a visiting Nganda, I need to plan very nice dishes for the whole period of dances. I prepare and plan how to serve very nice dishes of our delicious fish like Kampango, Nkhomo, goat meat and chickens. All meals are best served with tea too. I also plan to serve very good tea which has to be with milk. If I don't have goat milk, I plan to buy. I do my best to host my friend because on return visit they also serve nice meals.

Families hosting a friend during village dances need to prepare dishes to be served to the visitors for that particular week-end. Usually, *Nganda* and C*hioda* takes place at different times of the year. Preparations for *Nganda* festivals include ensuring to serve better relish, most preferably fish species like *Kampango* or *Nkhomo*, goat meat, and chicken. These main meals are preceded by the serving of tea. *Chioda* festivals are in fact known to serve more tea than *Nganda* as they serve tea also in the afternoon.

Goat milk as special food

Two key informants told that goat milk is used as a supplement to children after six months of exclusive breast feeding for HIV positive mothers. HIV positive mothers are advised by UNICEF, UNAIDS and UNFPA (2003) to exclusively breast feed for six months if they cannot afford to use acceptable, feasible, affordable, sustainable and safe (AFASS) replacement-feeding options. Six months exclusive breast feeding is associated with a lower risk of HIV transmission than mixed feeding (Coutsoudis et al. 2001). After six months of exclusive breast feeding, poor women, who cannot afford children formulas on Likoma can negotiate with goat farmers who are milking goats to sell to them 300mls of goat milk daily. Goat farmers who are milking goats prioritize supply of milk to women with a child. Milk supply for child supplementation is prioritized by milking goat farmers because they feel compelled to save a life

which is part of the village to which they also belong. A goat farmer supplying milk to an HIV positive mother put it this way:

HIV positive mothers share their challenge of how to get child supplementation feed with milking goat farmers. And when we are selling excess milk we prioritize our own village children who have challenges to continue breast feeding because of HIV/Aids. As a community, it is our responsibility to help them, they are our own children and serving life is of greater joy.

Goat rearing on Likoma is practiced through a local system of goat loan known as *kuweta* (Chichewa for 'rearing'). In the *kuweta* system, a goat keeper lends a mature female goat to a borrower who re-pays with after approximately one year. This gives a long-time interaction between lender and borrower. Sixty-five percent of the household interviewed got their first stock in goat rearing through the *kuweta* system. In households interviewed, 40% of milking hh and 28% on non-milking hh were involved in goat loans. At least once, 71% of farmers milking local goats had given one female goat on loan, with 69% for non-milking goat farmers.

Sixty-nine percent of the borrowers were related to the goat lender through kinship. The elderly responsible brother (*mwini mbumba in Chichewa)* lends goats to all sisters and after that to other relations or friends. Also among members of the same church, there is a high incidence of goat loans. Not only the borrower, but also the lender in *kuweta* systems benefit. For them it is a way of ensuring their flock, as lent-out goats serve as a reserve flock in case of outbreak of disease. Lending and borrowing goats serve to strengthen social relations, and 'glues' the community in Likoma. Borrowers who get a loan through friendship qualify by being trustworthy, expressing interest in goat rearing, or simply by making a request.

Some goats are reared on free range or tethered only in the growing season. But some goats always break off the tethering ropes and feed on other people's crop fields. The community chief charges a fine of 500 MKW or more depending on the extent of damage to goat owners whose goats have destroyed other

farmer's crop fields. Still goat keepers summoned to make payment for crops destroyed, enjoy sympathy if the offended is a fellow goat farmer. There is a shared understanding regarding offences when goats destroy crops. Goat keepers know that next time it would be their goat that is destroying crops, and would themselves, want to be treated kindly. As expressed by several farmers, in the following way:

When you keep goats and tether them, you know that goats can pull the tethering rope and break it if it is not strong enough. It is not easy to have strong ropes all the time, rope wear out and when you don't expect, it is too weak to hold your goat a whole day.

Implication of social values in introduction of livestock interventions: learning from goat milking communities on Likoma Island

The technologies in use in a particular society will reflect the interplay between cultural values, social concerns and material needs in the communities within which they are used. But they also create meaning for the members of that particular community (Meghani 2008):31). Livestock interventions that take into account the beliefs and concerns of a particular culture in its development of the intervention can be spared from failing such as livestock when interventions flop. Where livestock interventions have been planned without taking into account cultural values, researchers or project implementers can benefit by engaging in a respectful dialogue with those who express reservations about particular technologies, because of social values or ethical values coded in them, as they are likely to bring up awareness of missing links in wasted efforts of implementing a failing project intervention.

Tea culture as celebrated in Likoma, expressing both identity and social motivation, holds the life line of milk goat rearing in the community. Studies carried out in various societies show that food, including tea, is used to maintain the ethnic identity of groups, as well as families (Brown & Mussell 1984; Gabbacia 1998; Lockwood & Lockwood 2000). Food identities are shown through food festivals in an effort to maintain historically validated identities. Food can also be made an icon of ethnic groups 'resilience in times of hunger that the identities expressed through cherished food had nothing to do with the tastiness'

of the food (Diner 2003). In Likoma, tea drinking transcends festivals, it includes moaning periods, it is essential to survival in times of food shortage, it is an element in ordinary daily meals and a sign of life after food shortage. Tea is thus drunk in festivals of inter-village traditional dances, served at funeral gatherings, in daily-food meals during the day along with other dishes or alone, as the only meal in times of food shortage, and as a first essential when recovering from lack of food within a household. As community identity is so closely connected with tea drinking, goat milk rearing found an established niche in this society, because it enhances cultural values within community. Goat milk is considered to add value to tea as a more appreciated gesture in welcoming visitors, in festivals and ceremonies, and in offering tea to honorable visitors during funeral. This tea culture is passed from one generation to the other. But we know that each continuing generation also modifies the tradition according to current opportunities and challenges (Gvion 2009). On this basis we can also explain why those who can afford it prefer to use powdered milk instead of goat milk.

For poorer people goat milk rearing in Likoma offers protection from uncertain fishing incomes and fits well with the daily work schedules. During periods when fish catches drastically drop, or fail because of bad weather at the lake, goats become essential as livestock to be sold for household income to buy food. In addition, when dry fish sales are not profitable on the mainland and business men and women lose capital, goats offer alternative stand- by capital.

Within the resource context of Likoma, livestock species that do not compete with man for feed are ideal because of lack of resources. Importing feed requires a great income reserve, and in times of dwindling fish catches in Lake Malawi, relying only on fish income would be stressful for the household. Goat rearing fits well since goats feed of grass and bushes in the rainy season and survive mostly of tree leave supplement in the dry season. Goat rearing methods in use allow for flexibility to allow household members to engage in other livelihood activities. Men and mature boys go fishing at night and come back in the morning. As men are resting, women and men, when available, untether goats, from the night holding ground to tether at a feeding spot. Women are able to go and buy fresh fish early in the morning,

around 4 or 5 am, and process it and leave to dry; then come back to milk and tether the goat on a feeding spot. Goat milk rearing does not rob the family of time to engage in fishing and fish buying and processing. When household members travel, goats are left in the care of a family friend or relatives who also keep goats. Other than contributing to survival skills of Likoma community in times of food shortage, the goat milk plays a key role in festivals and ceremonies that link goat rearing to core cultural values. As such, households belonging to different extended families ensure that they own goats. Family leaders ensure that each one has a goat to increase the resource base in times of need. A mature female goat is loaned to kinship relations and marriage relations and also to friends. The perception of the community of goat rearing as a resource bank allows for self-propagation of goat rearing, which also ensures provision of goat milk.

Social cohesion emanating from promotion of milk goat rearing by farmers themselves has a positive feedback. There is much empirical evidence that farmer learn from other farmers cultivating same crop (Foster & Rosenzweig 1995; Munshi 2004). As goat keepers on Likoma loan each other's goats, goat rearing becomes a social value as one starts goat rearing through establishing informal lender-borrower linkages with fellow goat keepers. And milk goat rearing is not only for a special group of people, membership is open. Since goat rearing is for everybody, goat rearing has become important in social capital building for sustainable rural livelihoods. The community perceives goat rearing as a resource each one can tap into and better their own life.

Goat loans through the *kuweta* system within the community provide a platform for exchange of information and farmer to farmer learning, and a basis to ensure success for new adopters. Households borrowing goats on loan benefit from hands-on and shared experiences from the goat lender. Informal and close contacts with goat owners in the community offers better knowledge transfer and sharing from lead farmers to enable success of goat milk rearing. This finding is in agreement with technology adoption studies of farmers which indicate that farmers decisions to adopt correlate with both choice of their network of family and friends and also members of the same church (Bandiera & Russel 2006):871).

Goat farmers lend out goat to relations and trust-worthy friends or community members. These loans are based on trust and trust is glue in social networks (Gambetta 1988). The high numbers of lending to kinship reflect that goat farmers trusted most those they were affiliated to.

In this context, how do we explain changes in preference for powdered milk to goat milk on Likoma? We believe it is linked to changes and differences and social status. Non milking hh tended to be of higher education status, harvested higher quantities of cassava and earned less income as casual labors and small business of selling fry fish. Poor households and hh of lower education to a greater extent engaged in milking goats. As the social status changed, many preferred powdered milk. But they maintain Likoma tea culture! With more economic resources they have more options for obtaining milk for tea, and at the same time prefer fast growth rate for kids.

Appendix I

Figure 1: Location of Likoma Island in Malawi

Source: http:// africasafaris.co. 25 November, 2010, 11:20 hrs

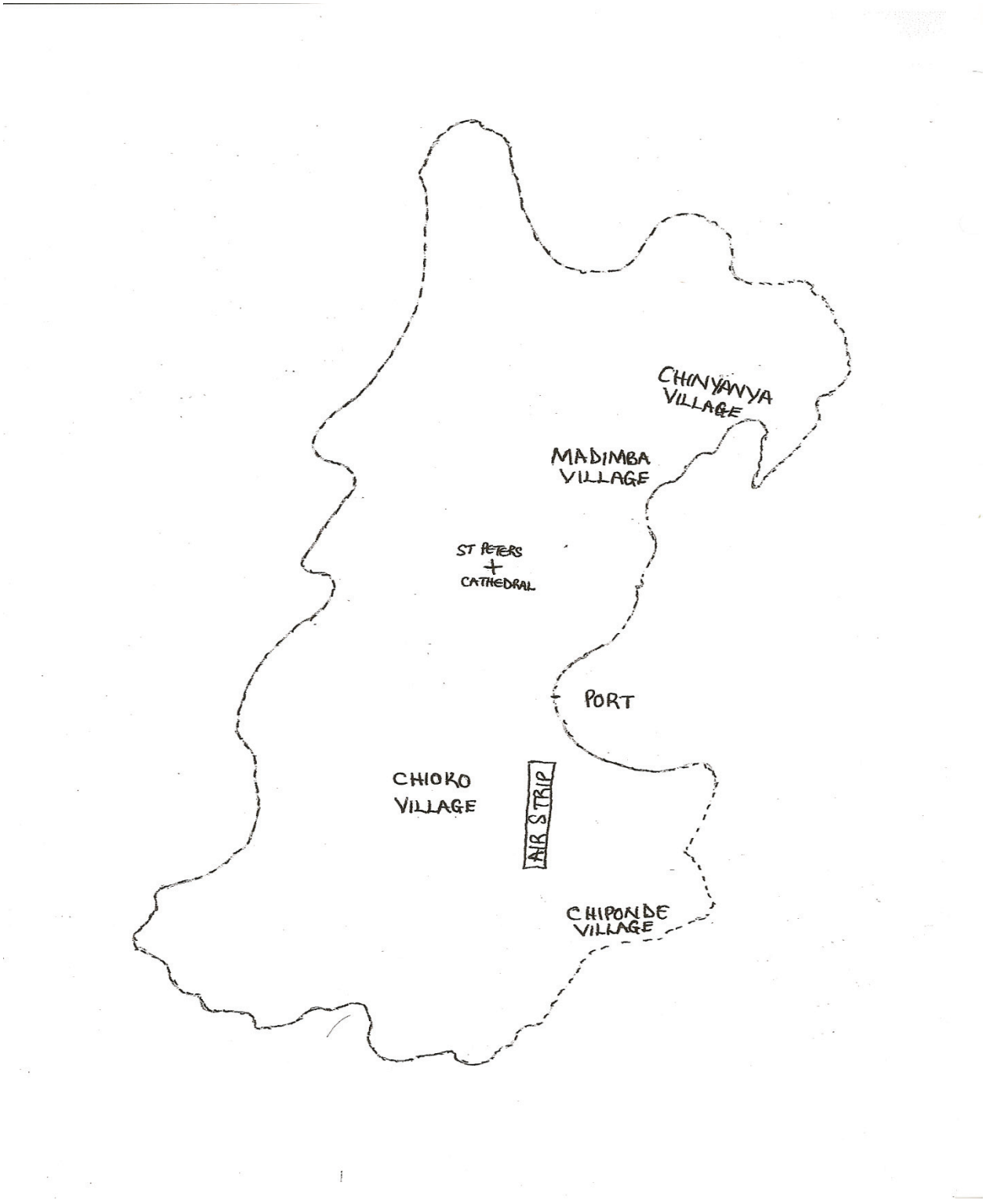

Figure 2: Sketch map of Likoma Island with villages covered by the study

UNICEF: The United Nations Children's Fund

UNFPA : United Nations Population Fund

UNIAIDS: The joint United Nations Programme on HIV/AIDS

WHO : The World Health Organization

HIV positive **:** refers to people who have taken an HIV test and who know that they are tested positive.

AFASS: acceptable, feasible, affordable, sustainable and safe replacement feeding

Exclusive breast feeding: an infant receives only breast milk an no other liquids or solids, not even water, with the exception of drops of syrup consisting of vitamins, mineral supplements or medicines.

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