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***Characterization and analysis of the urban and peri-urban
dairy production systems in the North western Ethiopian
highlands***

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Dedicated
to
my beloved father Alemayehu Ayenew

Abbreviations/Acronyms

ADF	Acid detergent fibre
ADL	Acid detergent lignin
AFC	Age at first calving
AI	Artificial Insemination
AOAC	Association of Official Analytical Chemists
CACC	Central Agricultural Census Commission
Ca	Calcium
CI	Calving interval
CP	Crude protein
CSA	Central Statistical Authority
DM	Dry matter
DoARD	Department of Agriculture and Rural Development
EEA	Ethiopian Economic Association
ESAP	Ethiopian Society of Animal Production
ha	Hectare
HL	Herd life
ILCA	International Livestock Research Institute
ILDP	Integrated Livestock Development Project
IVOMD	In vitro organic matter digestibility
LL	Lactation length
LS	Least-squares
MSE	Mean-square error
N	Number of observations
N	Nitrogen
n.e.	Not estimated
NDF	Neutral detergent fibre
NGO	Non-governmental Organizations
NMSA	National Metrological Service Agency
NSC	Number of services per conception
P	Phosphorus

p	Probability
r	Correlation
SD	Standard deviation
TLU	Tropical livestock unit
UNICEF	United Nations

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Chapter 1

General introduction

1. General introduction

1.1. Thesis outline

This thesis is divided into six chapters; the first chapter is a general introduction. Chapter 2, 3 and 4 are presented in the form of an article for journal publication and the first and second papers have been submitted for publication to the journal “Tropical Animal Health and Production” and are currently under review. The third one is in preparation to be submitted to the Journal “Livestock Research for Development”. In these three papers (2-4), the title, objectives, methods of investigation, the results and discussions and the concluding remarks are presented.

The first chapter is a general introduction, a description of the general farming and dairy production systems of Ethiopia, objectives and a description of the study area are presented. Chapter 2 assess the socio-economic characteristics of the urban and peri-urban dairying in the milk shed areas of North western Ethiopian highlands. The household characteristics, different income sources and farm activities, herd size and management systems and market access and different input services which are important for the development of dairy production are best described. Chapter 3 presents the productive and reproductive performance of dairy cows across the urban and peri-urban dairy production systems. Based on breed, land size of the dairy farmers, feed availability to dairy cows, and market access to sell dairy products of the urban and peri-urban dairy systems are briefly elaborated. In chapter 4, the milk utilization systems, the existing milk handling and processing systems as well as the marketing channels and major constraints are presented.

In chapter 5, the salient points of the thesis are discussed and general conclusions and recommendations for future studies are presented. The summary of the study written both in English and German is presented in chapter 6. Next to chapter 6, the combined references list for chapter 1 and 5 is presented.

1.2. General farming systems

The highlands have the highest density of both the human and livestock populations of any major ecological zone in sub-Saharan Africa. About 88% of the human population, 70% of cattle and sheep, 30% of goats and 80% of equines are found in this region (Alemayehu, 2004). The Ethiopian highlands (above 1500m a.s.l., receiving more than 700mm annual rainfall and with less than 20°C mean daily temperature) cover 490,000 km² or about 40% of the country and almost half of the total African highland area (FAO, 1986). In Ethiopia 85% of the population depends on agriculture for their livelihood. Agriculture is the basis for the economic development of Ethiopia and provides about 80% of total employment, and is the source of 85% of earnings from export (EEA, 2002). Globally, livestock contribute significantly to food production and economic output. Even though, the relative contribution of livestock to agricultural GDP is higher in the developed countries the trend has been slightly downwards since the past 30 years, while in developing countries the contribution of livestock is increasing (FAO, 2001). Ethiopia has the largest livestock population in Africa with approximately 41 million head of cattle including about six million draught oxen. About 80% of these animals are raised in the intensively cultivated highland of the country. Livestock is an integral component for most of the agricultural activities in the country which contributes about 33 and 12% of the agricultural and total gross domestic product, respectively, and accounts for 12-15% of the total export earnings (Ayele et al., 2003). In addition to the well known contributions as source of draught power, income and employment, food, manure and transport; livestock serve as an asset and escape of poverty in times of crop failure (Zinash and Azage, 2000; Ayele et al., 2003).

Crop production and livestock husbandry are commonly integrated in the mixed farming system of the medium-highland zones of Ethiopia. Land use is dominated by mixed smallholder rain-fed agriculture producing cereals, pulses and livestock. In Ethiopia, about six million hectare of land are put under annual grain crops; mainly wheat, barley, teff, maize, sorghum and pulses. Oxen are important suppliers of draught power for land development, tillage, threshing and transport. The more crop production is increased, more and more oxen are required. About 7 million head of equines are used extensively for transport of agricultural and non-agricultural goods (CSA,

2003). This fact is even more important in most parts of high potential agricultural zones of Ethiopian highlands due to the uneven nature of the landscape.

As more and more land is put under crop production, livestock feed becomes scarce and crop residues particularly cereal straws remain the major feed source for the animals particularly during the dry period of the year (November to May).

1.3. Dairy production systems

Globally, the demand for milk and milk products is estimated to grow due to the high population growth and increasing urbanization (de Leeuw et al., 1999). The highest growth in demand is expected from developing countries (Griffin, 1999). In sub-Saharan Africa the demand for milk and milk products is expected to grow at an annual rate of 3.3% (Delgado et al., 2001). In line with this, world milk production is expected to grow by an annual rate of slightly over 1%, while the highest increment is expected from developing countries in which from 1997 to 2020, the annual milk production is projected to grow at a rate of 2.73%. Therefore, it is observed that even after a decade meeting the demand of people for milk and milk products is questionable.

In sub-Saharan Africa, three quarters of the milk is produced by cattle, the remainder coming from camels and goats, which are mainly reared in the arid zones, while in Asia nearly half (47%) of the milk is from cattle and the rest is produced from buffalo (Walshe et al., 1991). Like in Central and South America, in Ethiopia, cows are the main source of milk for human consumption. Ethiopia stands first from Africa and 10th from the world in terms of livestock population, which is about 41,14, 13, 1, 3, 0.3, 0.4 and 42 million of cattle, sheep, goat, horses, asses, mules, camels and poultry, respectively (CACC, 2003). In addition, the country enjoys diverse topographic and climatic conditions which could support the use of improved breeds of cows and offers a relatively disease free environment for livestock development. However, the productivity of them is very low. The estimated annual milk production for cattle is about 800,000 metric tones and the annual per capita milk consumption is 25.6 kg/year. This consumption is low compared to the other sub-Saharan African countries and far below the 200 kg/year of developed countries (ILCA, 1993).

Dairy production is a biologically efficient system that converts large quantities of roughage, the most abundant feed in the tropics, to milk, the most nutritious food known to man. Where there is access to a market, both for the milk sales and input acquisition, dairying is preferred to meat production since it makes more efficient use of feed resources and provides a regular income to the producer (Walshe et al., 1991). Dairy production is also more labour intensive and supports substantial employment in production, processing and marketing (Walshe et al., 1991) and hence it gives more job opportunities for most jobless urban dwellers of the tropics (Azage and Alemu, 1998).

Higher levels of production than those achieved in traditional tropical systems, often require the introduction of specialised dairy breeds and increased levels of inputs (nutrition and health care) and good linkages to markets. Hence, the intensification of smallholder livestock production systems in general and dairy production systems in particular is mainly concentrated in areas with good infrastructure close to major markets, although less intensive production may occur in other, more distant areas (Walshe et al., 1991). These market factors, therefore, play a major part in determining the type of dairy production systems found in the tropics, and they are particularly important influences on smallholder dairy development. Therefore, dairy production systems in the tropics are mainly concentrated near consumption centres and it is no coincidence that cattle and rural human population densities are highly correlated (Kruska et al., 1997), with specialized smallholder (and large scale) dairy farms generally located close to (peri-urban) or within (intra-urban) major markets, or more distant when there is an efficient market infrastructure. On the other hand, the systems of production and their productivity are influenced by agro-ecological factors and traditional consumption habits (de Leeuw et al., 1999).

Like most dairy systems found in the tropics, the Ethiopian dairy system includes large number from small to large-sized and subsistence to market-oriented farms. Based on climate, land holdings and integration with crop production as criterion, three major dairy production systems are recognized in Ethiopia (Azage and Alemu, 1998; Ketema, 2000; Tsehay, 2001; Yoseph et al., 2003; Zegeye, 2003; Dereje et al., 2005, Sintayehu et al., 2008). The first one is the urban dairy production system involving from smallholder to highly specialized dairy farms. The second one is the peri-urban system which is found in the outskirts of the capital city and regional cities,

which includes commercial to smallholder dairy farms. The third one is the rural dairy system which is part of the subsistence farming system and includes pastoralists, agro-pastoralists, and mixed crop–livestock producers (Azage and Alemu, 1998; Ketema, 2000; Tsehay, 2001; Yoseph et al., 2003; Zegeye, 2003; Dereje et al., 2005; Sintayehu et al., 2008)).

Urban dairy production system includes from smallholder to highly specialized, state or businessmen owned farms, which are mainly concentrated in major cities of the country. These dairy farmers have no access to grazing land. Currently, a number of smallholder and commercial dairy farms are emerging mainly in the urban and peri-urban areas of the capital (Felleke and Geda, 2001; Azage, 2003) and most regional towns and districts (Anthony, 2002; Nigussie, 2006). Smallholder rural dairy farms are also increasing in number in areas where there is market access. According to Azage and Alemu (1998), the urban milk system in Addis Ababa consists of 5167 small, medium and large dairy farms producing 34.65 million litres of milk annually. Of the total urban milk production, 73% is sold, 10% is left for household consumption, 9.4% is fed to calves (excluding the amount directly suckled by the calves) and 7.6% is processed into butter and cottage cheese. In terms of marketing, 71% of the producers sell milk directly to consumers and the rest reaches to the consumers through intermediaries (Tsehay, 2001).

Peri-urban milk production is developed in areas where the population density is high and agricultural land is shrinking due to urbanization around big cities like Addis Ababa and other regional towns. In this system crossbred animals ranging from F1 (50%) up to animals with a higher blood level of exotic breeds (mainly Holstein Friesian) are kept in small to medium-sized farms. This peri-urban dairy production system includes commercial to smallholder dairy farmers. Such farmers are reported to be found in the proximity of major cities (Addis Ababa) and other regional towns. This sector own most of the country's improved dairy stock (Tsehay, 2001; Mohamed et al., 2003; Sintayehu et al., 2008). The main source of feed is both home produced or purchased hay; and the primary objective is to get additional cash income from milk sale. This production system is now expanding in the highlands among mixed crop–livestock farmers, such as those found in Selale and Holetta, and serves as the major milk supplier to the urban market (Gebrewold et al., 2000).

The rural dairy production system is considered to be part of the subsistence farming system. The system comprises pastoralist, agro-pastoralist and highland mixed crop-livestock dairy farming systems. It is characterized as non-market oriented system. As a result, most of the milk produced retained for household consumption. The amount of production of surplus milk is determined by the potential to produce milk in terms of herd size and composition, production season and access to the nearby market. Moreover, the amount of milk surplus is also detected by the demand of the household and their neighbours. Mostly, the farmers put milk and milk products for sale after the household demand is being satisfied. Therefore, such surplus milk is processed traditionally into butter, cottage cheese and sour milk and put to the local market informally (Mohamed et al., 2003). Pastoralists raise about 30% of the indigenous livestock population which serve as the major milk production system for an estimated 10% of the country's human population living in the lowland areas. Milk production in this system is characterized by low yield and seasonal availability (Zegeye, 2003).

Specific objectives

The objectives of the study “Characterization and analysis of the urban and peri-urban dairy production systems in North western Ethiopian highlands” were to:

- provide baseline data describing the status of the dairy production system;
- identify dairy farmers' objectives and understand factors influencing dairy production system and opportunities available to increased production;
- understand linkages between the dairy production systems and utilization, processing and marketing systems, and their influences on production;
- identify recommendation domains for developing policy and technical interventions; and,
- identify and prioritize researchable issues that, if addressed, will be expected to generate technologies that can impact positively on the dairy system development.

1.4. The study areas

The study was conducted in two milk shed areas of the North western Ethiopian highlands, Bahir Dar and Gondar (Fig. 1). The area lies on an elevated plateau ranging from 1720 to 3000 m above sea level. The average annual temperature and rainfall range from 10 to 30 °C and from 1000 to 1500 mm, respectively (NMSA, 2008). Bahir Dar is a city in north western Ethiopia, and the capital of the Amhara Region. The city is located approximately 578 km north-northwest of Addis Ababa, having a latitude and longitude of 11°36'N 37°23'E and an elevation of 1840m above sea level. Bahir Dar is not only one of the largest towns in Ethiopia, but also one of the fastest growing cities in the country. Gondar is located in the North Gondar Zone of the Amhara Region. The city has latitude and longitude of 12°36'N 37°28'E with an elevation of 2133 meters above sea level.

The study sites comprise a total of 17 administrative districts (Bahir Dar, Bahir Dar Zuria, Achefer, Merawi, Dangla, Banja, Fagta, Fogera, Libo Kemkem, Farta, Debre Tabor, Gondar, Gondar Zuria, Dembia, Wogera, Dabat and Debark) (Fig. 2). According to the CACC (2003a) report, the urban (including zonal and district towns) and rural areas of these districts were estimated to comprise about 2.28 and 0.09 million households, respectively. The total population of the study sites was 11.9 million, while the total number of milking cows was about 387,000 (374,000 and 13,000 for rural and urban areas, respectively). The calculated average size of land per household which was assigned to the production of annual crops, perennial crops, for grazing and other purposes was about 0.99, 0.02, 0.18 and 0.07 hectare, respectively (CACC, 2003b).

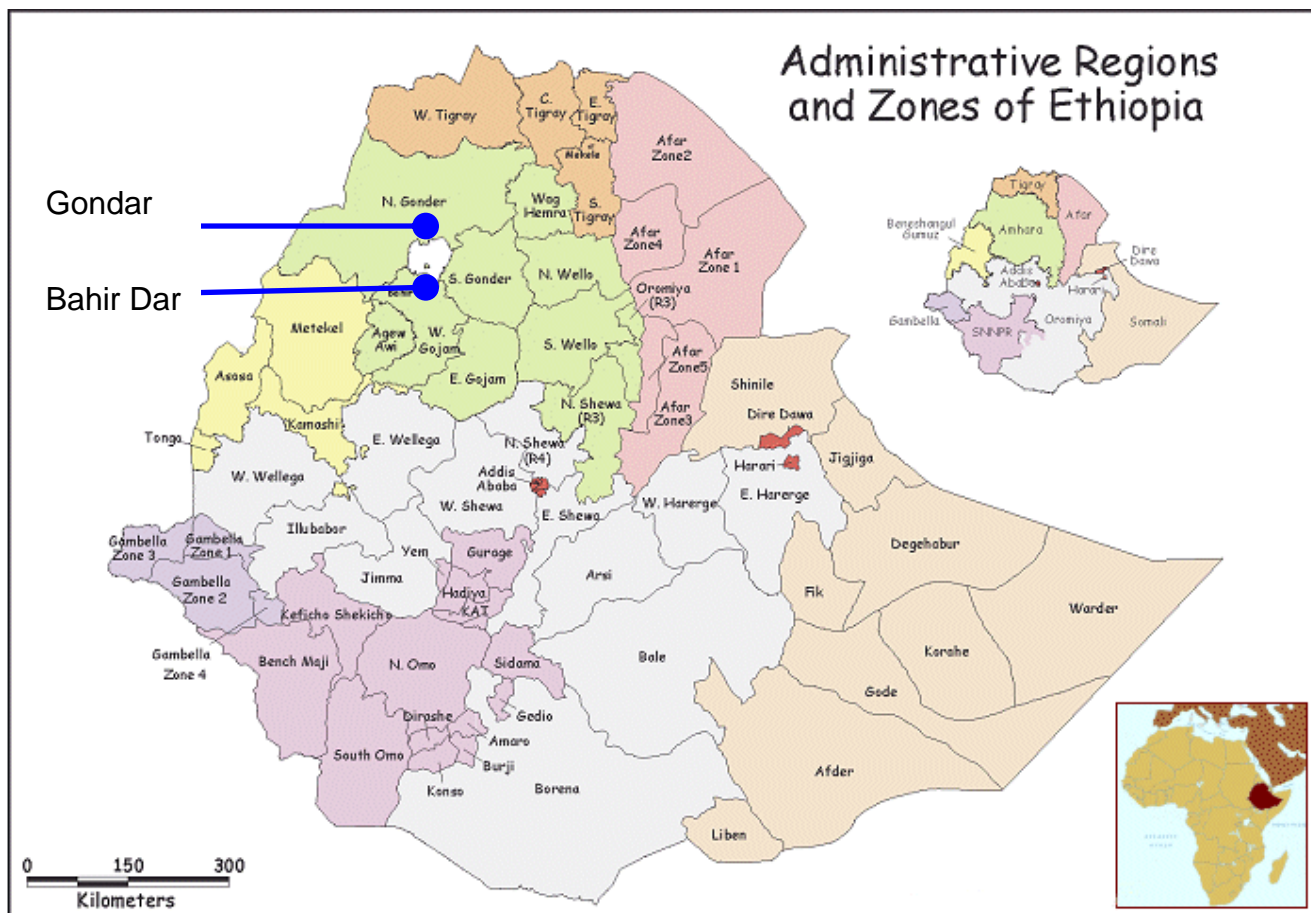


Fig. 1 Study area in North western Ethiopia



Fig. 2 Location of study districts in North western Ethiopia

Chapter 2

Socio-economic characteristics of urban and peri-urban dairy production systems in the North western Ethiopian highlands

2. Socio-economic characteristics of urban and peri-urban dairy production systems in the North western Ethiopian highlands

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Keywords: Cattle, dairy, Ethiopia, peri-urban agriculture, socio-economy, urban agriculture

Abstract: In order to evaluate the socio-economic characteristics of urban and peri-urban dairy production systems in the North western Ethiopian highlands, a field survey were conducted which included 256 smallholder farmers. It is concluded that urban farmers tend to specialize on dairy production and support the family income from non-agricultural activities, while agricultural activities other than milk production forms an additional source of income in peri-urban farms. The specialization of urban dairy producers includes the more frequent use of crossbred cows with higher milk yield. Urban and peri-urban dairy production contributes to food security of the population and family income of the farmers' families, but also provides a job opportunity for otherwise unemployed people. Access to farm land, level of education and access to certain input services such as training, veterinary and credit services were identified as the major constraints for the future development of the dairy sector.

Abbreviations

AI	Artificial Insemination
CSA	Central Statistical Authority
ESAP	Ethiopian Society of Animal Production
ha	hectare
MSE	mean-square error
N	number of observations
NMSA	National Metrological Service Agency
p	probability
r	correlation

2.1 Introduction

Today urbanisation is advancing at a much more rapid rate than ever. Sub-Saharan Africa is approaching a demographic inflection point as the numbers of new urban residents are projected to rise sharply by over 300 million between 2000 and 2030 which is more than twice the rural population increment (World Bank, 2005). Meeting the demand for food in general and for protein in particular of these people will present an enormous challenge to African farmers and the governments for whom welfare of urban consumers is becoming a major political concern. Urgent attention is required to provide food for this growing demand. Much of the increased demand for dairy products will be concentrated in urban and peri-urban areas. Hence, development of the production and productivity of the livestock sector can play a vital role in fulfilling the growing demand for protein (Azage and Alemu, 1998). The fast growth rate of urbanisation could accelerate the demand for food of animal origin; increasing income strata among urban people, depressed economic situation which does not allow to import dairy products and dwindling food aid has given a chance to the emergence of market oriented commercial large scale and smallholder urban and peri-urban dairying in tropical and sub-tropical countries.

Based on geographical location and spatial land use, several researchers (Gündel, 2006; van Veenhuizen and Danso, 2007) have tried to clearly distinguish between urban and peri-urban agriculture. Urban agriculture includes farming activities taking place within the inner cities and major towns, utilizing vacant and under-utilized land areas not suited for construction, home and institutional gardens. On the other hand, peri-urban agriculture includes farming in the urban periphery; this type of agriculture tends to undergo dramatic changes over a given period of time, as there is an influx of people from both rural and urban areas.

In Ethiopia urban and peri-urban dairying constitutes an important sub-sector of the agricultural production system. Urban and peri-urban dairy production systems involve production, processing and marketing of milk and milk products that are channelled to urban centres. It plays a vital role in the lives of the urban and peri-urban poor by providing a source of subsistence through household nutrition (milk and meat), supplementary income and generating employment opportunity. To address such objectives, modern dairy farming in Ethiopia started in the early 1950s with the importation of exotic dairy cattle by the United Nations Relief and Rehabilitation

Administration (UNRRA). Following this idea, several governmental and non-governmental organizations have launched dairy development projects in urban and peri-urban areas of Ethiopia (Mohamed *et al.*, 2003). However, many livestock development projects in Ethiopia have failed to meet their objectives (Lobago *et al.*, 2007). Most of the problems are the result of inability to identify appropriate technologies and define the livestock production practices and constraints.

Urban and peri-urban dairy production systems in Ethiopia are constrained by several factors such as technical, socio-economic and institutional factors (Fekadu, 1994). Hence, in order to attain sustainable livestock development, careful planning is required for the generation of appropriate and demand driven technologies. Therefore, it is justifiable to assess and recommend some technical issues for smallholder dairy farmers. Adoption of technical recommendations at the farm level is dependent on the social, cultural, economic and environmental conditions facing the farmers who own and use the animals (Solano *et al.*, 2000). However, information on the type and level of socio-economic factors affecting dairy production systems either positively or negatively is limited in the studied areas. Therefore, this study was conducted with the specific objectives to assess the socio-economic characteristics of the dairy production systems and to suggest appropriate intervention areas of the urban and peri-urban dairy production systems in the milk shed areas of the North western Ethiopian highlands.

2.2. Materials and Methods

2.2.1. Study areas and data collection

The study was conducted between July 2006 and March 2007 in order to analyse the socio-economic characteristics of urban and peri-urban dairy production systems in the milk shed areas of Bahir Dar and Gondar, North western Ethiopian highlands. As mentioned above, the urban production system deals with primary dairy supply chains in the inner cities and major towns, while the peri-urban system includes farms found in the periphery of cities and secondary towns. The study areas are located on an elevated plateau ranging from 1720 to 3000 m above sea level. The average annual temperature and rainfall range from 10 to 30 °C and from 1000 to 1500 mm, respectively (NMSA, 2008).

In a first step, a rapid survey was conducted at district level with the Agriculture and Rural Development Offices in order to identify dairy farmers who keep different cattle breeds and represent different farming systems and milk production potentials in varying agro-ecological zones; information from 19 districts was collected. Based on this information, a total of 256 dairy farmers were chosen from 17 districts using random sampling technique (Table 1). After a pre-test of the questionnaire, farmers were individually interviewed. The questionnaire consisted of open and closed questions, all of which were translated into the local language. The questionnaire covered a large range of topics including general information about household characteristics, income sources and farm activities, herd size and composition, herd management practices and type and extent of institutional support.

2.2.2. Data analysis

Location (urban and peri-urban) and farming system were used as fixed factors for most dependent variables such as family size, farm size, herd composition and herd structure. Except for cattle number, preliminary analysis showed that interaction effects of the fixed factors were not significant and hence were excluded from the model. Data were analysed using General Linear Model (GLM) procedures of the Statistical Analysis System (SAS, 2002). The model was $Y_{ijkl} = \mu + L_i + F_j + B_k + LF_{ij} + \varepsilon_{ijkl}$, where, Y_{ijkl} is the dependent variable, μ is the over all mean, L_i is the fixed effect of the location i , i =urban, peri-urban; F_j is the fixed effect of farming system j , j =livestock, crop-livestock; B_k is the fixed effect of the breed group k , k = local (Zebu type), local x Holstein Friesian; LF_{ij} is the interaction of location and farming system and ε_{ijkl} is the random error. Tukey's standardized range test was used for comparisons of means.

Chi-square-test was used to determine differences in percent frequency of ordinal data. The level of significance for more than two factor levels was analyzed with the Bonferroni-Holm test. Correlation analysis was done to determine the degree of relationship between random variables such as family size and land size. For all analysis, the level of significance was set at alpha of $p < 0.05$.

2.3. Results

2.3.1. Household characteristics

The average family size per household for different locations and farming systems is presented in Table 2. Family size was almost the same for both farming systems, but peri-urban farms had significantly ($p<0.05$) more household members than urban farms.

Overall, 27.7% of dairy farm owners were illiterate, 25.5% were able to write and read, and 19.6% had a higher education. Pair wise comparison showed no significant ($p>0.05$) differences between locations for the respective level of education (diploma and above education levels were 24.5 and 18.3% in urban and peri-urban areas, respectively). Regardless location, a significantly ($p<0.001$) greater percentage of male (87%) than of female household heads was observed. Illiteracy rate was significantly ($p<0.001$) higher among female than male household heads (60 versus 16%).

Assessment of the hired labour availability indicated that all of the urban farmers used hired labour, while only 85.8% of the peri-urban farmers employed people. Out of the urban farmers hiring labour, the majority (70.2%) employed labourer permanently, whereas only 54.7% of the peri-urban farmers did so. Generally, in all (256) dairy farmers interviewed, about 342 males and 90 females were hired labourers (Fig.1). The majority (84%) of the external labourers came from rural areas while 16% were hired from towns.

In urban farms a high percentage of hired labour (35%) was used for dairy-related activities such as herding, cleaning of the shed, carrying of suckling calves, feeding and milk processing, while in peri-urban areas mainly household labour (especially adult females with a contribution of 51%) was used. The decision makers for the amount of milk to be processed and sold were wives of the household head. However, high-level decisions such as purchasing and selling dairy cattle were mainly (90%) made by the household head.

2.3.2. Income sources and farm activities

The relative importance of different income sources showed a significantly ($p<0.001$) different pattern for urban and peri-urban areas (Fig. 2). In both areas, the contribution from dairying to the total household income was at the same level. But in peri-urban areas the second most important

income source are non-dairy farm activities (particularly crop farming), whereas in urban areas off-farm activities such as trading and civil work are much more important as additional source.

About 59% of the farmers interviewed actually own farm land (on average 1.6 ha, ranging from 0.01 to 16.1). In urban areas, where 70% of the farmers do not have access to farm land, livestock farming and especially dairying is by far the main agricultural activity. Average land size per farmer differed significantly ($p < 0.001$) between farming systems (3.1 and 0.3 ha for crop-livestock farmers and livestock farmers, respectively). Similarly, average farm size was significantly ($p < 0.001$) different between locations (2 and 0.6 ha for peri-urban and urban farms, respectively).

Overall, farmers allocated about 37.2, 21.2, 34.7 and 6.9% of their agricultural land for annual crop production, perennial crop and other plantation, grazing and cultivated pasture land, respectively. There were significant ($p < 0.001$) differences between farming systems in the size of land for annual crop and cultivated pasture production (2 versus less than 0.01 ha and 0.1 ha versus 0.03 ha for crop-livestock farmers versus livestock farmers, respectively). In this study, a positive correlation ($r = 0.23$, $p < 0.001$) between family size and farm size was observed.

In the study areas, cattle are kept as multi-purpose animals: source of milk, draught power, meat and manure production were mentioned by farmers in decreasing order of importance. An attempt made to evaluate the economic motivation of the respondent farmers for keeping cattle revealed that increasing family income (57.4%) was followed by household use (34.3%); only 8.3% of the farmers keep cattle as a living bank and sell them when there is a need of larger amounts of money.

2.3.3. Herd size and management

The average numbers of livestock owned by 256 farmers are presented in Table 3. However, the total number of cattle, local (Zebu type) and local x Holstein Friesian crossbred cows, heifers and calves owned by the respondent was significantly influenced by an interaction of location and farming system (Table 4).

In urban crop-livestock farms (mainly composed of governmental and non-governmental large farms), the total number of cattle per farm was higher (34) than for livestock farms (9.7). Similarly for peri-urban sites, the herd size was greater for crop-livestock farms (9.6 as compared to 6.5 for livestock farms). Local cows are mainly kept on peri-urban crop-livestock farms, where they constitute more than half of the cow population, while in the other locations and farming systems mainly crossbred cows are used.

One of the major problems in urban dairying was a lack of sufficient space for the dairy cows. The majority of the urban producers (80.7 %) were observed keeping dairy cattle in confined places of the same compound in which the household members were living. Among others, this practice might bear some hygienic risks. The availability of construction materials significantly ($p < 0.001$) affected selected characteristics of the barns: e.g. more earthen (38.3%) and stone paved (40%) floors were found in peri-urban farms, while concrete floors were dominant in urban farms (61.2%). In peri-urban farms, barns were cleaned two (56.8%) or three (32.7%) times a day, while in urban farms 32.8 and 50% of farmers cleaned two and three times in a day, respectively.

In urban areas manure collection, transport and disposal were generally chaotic. However, farmers were obliged to pile the cow dung outside of the farm which caused a nuisance to the area, including the risk of local pollution due to nutrient leaching.

2.3.4. Access to market and input services

In the study areas, the average annual milk production per farm was estimated to be about 10,526 and 4,020 liters for urban and peri-urban areas, respectively. Of the average milk produced, the proportion of fresh milk sold was significantly ($p < 0.05$) higher for urban farms (47%) as compared to that of peri-urban farms (21 %).

Artificial insemination (AI) was more frequently (57%) used than bull services and no significant ($p > 0.05$) differences were found in the breeding practice between locations and/or farming systems. In both locations the government is the only provider of AI service which is completely free of charge for peri-urban farmers, while in urban areas 14.6% of the respondents had to pay between 3.5 and 5.9 USD per cow for AI technicians. Generally, peri-urban farms had a

significantly ($p < 0.001$) better access to veterinary services than urban farms (90.4 as compared to 64.9%, respectively).

Only a small proportion of farmers (16%) got credit services for dairy related activities and this did not vary significantly ($p > 0.05$) between locations. Comparing training opportunities and access to extension service, a clear pattern can be observed. More than half (53.5%) of the peri-urban farmers, but only 16% of urban farmers ($p < 0.001$) had attended some form of training on dairy cattle management. In addition, peri-urban farmers had a significantly ($p < 0.05$) more frequent contact to extension agents than urban farmers: 55% of the peri-urban farmers had access to extension agents and the contact was about once in a month, while urban farmers had little access to extension agents and only 28% of the total farmers were visited once within four months.

2.4. Discussion

2.4.1. Household characteristics

The significantly greater family size per household in peri-urban farms than in urban farms (Table 2) is likely to influence labour capacity available for crop and livestock production. Hence, having more family members may be considered as an asset and a factor which increases social security in times of retirement. This might be one reason among others for the greater household size in peri-urban areas where the workload (in addition to dairying) for crop land preparation, manual weeding and harvesting of food is higher. This is in agreement with the report of ESAP (2002) for the case of Eastern Ethiopia.

The level of education of the household heads, who were also observed to be the managers of the farms (Yousuf Kurtu, 2003) did not differ much between different farming systems and locations, but illiteracy rate was almost three times higher among female as compared to male household heads. The percentage of the household heads possessing higher education (19.6%) was comparable to that reported by Yousuf Kurtu (2003) for the case of Harar milkshed (24%). Similar results were reported for Burkina Faso by Thys et al. (2005) who found a higher illiteracy rate among urban livestock keepers in Ouagadougou. Moreover, Yoseph et al. (2003) reported that smallholder urban and peri-urban dairy farms were run by resource-poor people, who were illiterate. A low level of education of the dairy farm owners might affect the level of potential

intensification of dairy production. The dominance of male household heads reported herein (87%) is in agreement with results published by Azage (2004) for Addis Ababa (Ethiopia), Swai et al. (2005) for Tanzania and Thys et al. (2005) for West African situation. This study demonstrated that dairy production does not only provide benefits for owners, but also is one option for employment. Similar results were reported by Azage et al (2006) who concluded that urban and peri-urban dairy production systems could contribute to overall development through income and employment generation.

In urban farms, the high percentage of involvement of hired labour (35%) was probably related to the more frequent engagement of both husbands and wives in off-farm activities such as civil work and trading than in peri-urban farms (Fig. 1 and 2). The dominant role of male household heads in economically highly relevant decision making is in agreement with Yoseph et al. (2003) and Yousuf Kurtu (2003) who worked in the milk shed areas of Addis Ababa and Harar region, respectively. However, wives decided about issues such as the amount of milk to be sold and processed.

2.4.2. Income sources and farm activities

Comparable to the report of Thys et al. (2005), fetching income was the main argument for keeping livestock in this study. In both study areas similar levels of contribution of dairying to the total household income were observed (Fig. 2). Comparable results were reported in various studies for the Ethiopian highlands in which dairying generated 34% of the total household income of farmers in the Holleta area (Mohamed et al., 2003) and 48.9% of the urban farmers of Southern Ethiopia (Sintayehu et al., 2008). However, the results from Sintayehu et al. (2008) about the contribution of dairying to the total household income in rural areas of Ethiopia was much lower (1.6%) than the current result for crop-livestock farmers in peri-urban areas (42%). Such differences might have resulted from a variation in herd size, productivity of dairy cattle, and level of income from other sources, farm size and access to input services (particularly artificial insemination, health, training, and credit services).

The contribution of non-dairy agricultural activities to the household income was higher in peri-urban than in urban farms (26% as compared to 3%; Fig. 2). The reason for a greater contribution of non-dairy farming to family income in peri-urban areas has to be seen in connection with a 10-

times greater farm size in peri-urban farms (3.1 ha) than urban farms (0.3 ha) and hence with the consequence of higher proportion of crop farmers (58.3%) as compared to urban areas. A consequence of the low farm size in urban areas is the substantial percentage of backyard dairy farmers without access to agricultural land (70.2%). However, the lives of many peri-urban farmers mainly depend on agriculture and the government had given them more land as compared to urban farmers. In Ethiopia, land is mainly distributed to farmers on the basis of their family size. In this study, a positive correlation ($r=0.23$, $p<0.001$) between family size and farm size was observed. This is supported by the review report of Getachew et al. (1993) and Kelay (2002) who stated that, since the land reform declaration of 1975, land was allocated to individual farmers of the peasant associations depending on family size, fertility of the land, the number of members and the total land area available within a peasant association.

Of the total farm land of the respondent farmers, the proportion of land allocated for annual and perennial food crop production was 58.4%, for private grazing 34.7% and for cultivated pasture land 6.9% of the total farm land. This implies that a large proportion of farm land was allocated to crop production, which is in agreement with reports of CSA (2003). In general, the decline in grazing land has become one of the most important causes of feed shortage and drop in livestock productivity (ESAP, 2002).

2.4.3. Herd size and management

The overall number of cattle owned by the respondent farmers were varied significantly between locations and farming systems (Table 3 and 4). In both study areas, crop-livestock farmers owned larger herds (34 and 9.6 for urban and peri-urban sites, respectively) than livestock farmers (9.7 and 6.5 for urban and peri-urban farms, respectively). The higher numbers of cattle in mixed crop-livestock farms has to be seen in connection with the larger farm size of crop-livestock farmers. For urban farmers usually only very little land is available, the animals are mostly kept in backyards. Yoseph et al. (2003) and Lobago et al. (2007) made similar observations in Addis Ababa and Sellale, Ethiopia, respectively. Moreover, Abdinasir (2000) explained that in the Arsi highlands of Ethiopia, the herd size increases significantly with the increment of the cultivated area. As it was also reported by other authors for mixed crop-livestock production systems of the Ethiopian highlands (Dereje et al., 2005; Sintayehu et al., 2008), in the cereal-based mixed farming systems more male calves were grown to assist the crop-production by providing draught

power. This might have also encouraged mixed crop-livestock dairy farmers to keep more non-dairy animals which contributed to the greater number of cattle in the area.

Like in other developing countries and despite the common confinement of dairy cattle in an urban environment, manure collection, transport and disposal were generally chaotic (Moses et al., 2004). Yousuf Kurtu (2003) also reported that the majority of urban farmers faced substantial problems concerning a proper manure disposal. The availability of adequate land for dairy production is therefore not only a matter of productivity, but also a precondition for proper waste management and utilization of manure as an input source for plant production or other purposes.

2.4.4. Access to market and input services

The proportion of milk sale was significantly higher in urban systems than in the – mainly peri-urban – mixed crop-livestock system. In the urban system, the high proportion of milk sale is probably connected to the increasing urbanization which demands more protein in the cities (Azage and Alemu, 1998). This result is comparable with the report of Sintayehu et al. (2008) who reported that a majority (79.2%) of the urban farmers produced milk for sale, while in peri-urban areas only about 13.7 % of the farmers produced milk for sale.

A significantly greater percentage of peri-urban than of urban farmers had attended some form of training on dairy cattle management. These numbers are lower than those reported earlier for Tanzania (Swai et al., 2005). Only a very limited access to credit services was observed in both areas, as only 16% of the farms made use of credit services for dairy production. Compared to this, a substantially higher percentage of farmers relied on veterinary services, which were demanded significantly more frequently by peri-urban farmers as compared to urban farmers. This difference can be explained by a relatively low government focus on urban dairy farming as compared to peri-urban farming; e.g. no veterinary staffs was available in one of the major towns, Bahir Dar. This deficit has already been identified some 15 years ago, when it was reported that in Ethiopia urban farming is being carried out mainly as a result of low income level and unemployment, usually utilizing vacant space (Davinder, 1993). Moreover, urban agriculture is done on land in transitional use and where rights of usufruct are at issue. The uncertainties originating from this lead to low investment and consequently to low productivity. Davinder

(1993) already emphasized that policy for urban agriculture and extension services are sparse in Ethiopia and in the study areas this deficit seemed to continue.

2.5. Conclusions

From the data presented here, it is concluded that urban farmers tend to specialize on dairy production which forms the second most important source of family income. This specialization of urban dairy producers includes the more frequent use of crosses from local and exotic cattle with a higher performance. Unlike for peri-urban farmers, the production of other agricultural commodities is not an option for urban farmers, mainly due to a lack of agricultural land available to them.

The great potential of urban and peri-urban dairy production for contribution to food security of the population, to family income, but also as a job opportunity will be better realized if current deficiencies in the access to services such as the transfer of technical knowledge, artificial insemination, veterinary and credit services are resolved. Limitations in the access both to agricultural land (especially for urban producers) and market sites (for peri-urban farmers) are also likely to hamper the development of this sector and need to be addressed by specific policy schemes. Another element of the production chain which deserves special attention is the currently poor manure collection, transport and disposal in urban areas and the potential health hazards and environmental pollution originating from this.

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Table 1 Number and proportion of farmers engaged in different farming systems by location

<i>Locations</i>	<i>Farming systems</i>			
	<i>Livestock</i>		<i>Crop-livestock</i>	
	<i>number of farmers</i>	<i>%</i>	<i>number of farmers</i>	<i>%</i>
<i>Urban</i>	<i>51</i>	<i>89.5</i>	<i>6</i>	<i>10.5</i>
<i>Peri-urban</i>	<i>83</i>	<i>41.7</i>	<i>116</i>	<i>58.3</i>
<i>Total</i>	<i>134</i>	<i>52.3</i>	<i>122</i>	<i>47.7</i>

Table 2 Family size by location and farming system

<i>Factors</i>		<i>N</i>	<i>Family size</i>	<i>Root MSE</i>	<i>P-value</i>
<i>Locations</i>	<i>Urban</i>	<i>52</i>	<i>6.0</i>	<i>2.8</i>	<i>0.015</i>
	<i>Peri-urban</i>	<i>197</i>	<i>7.1</i>		
<i>Farming systems</i>	<i>Livestock</i>	<i>131</i>	<i>6.7</i>	<i>2.8</i>	<i>0.403</i>
	<i>Crop-livestock</i>	<i>118</i>	<i>7.0</i>		

Table 3 Least-squares means for livestock herd size and composition (N = 256)

<i>Livestock species</i>	<i>Locations</i>		<i>Range</i>	<i>Root MSE</i>	<i>P_{location}</i>
	<i>Urban</i>	<i>Peri-urban</i>			
<i>Cattle</i>	21.8	8.1	1 – 92	7.9	<0.001
<i>Sheep</i>	1.6	3.1	0 – 65	7.2	0.359
<i>Goats</i>	0.02	0.4	0 - 20	1.8	0.309
<i>Horses</i>	0.1	0.3	0 – 5	0.7	0.291
<i>Donkeys</i>	0.1	0.4	0 – 8	0.9	0.176
<i>Mules</i>	0.1	0.1	0 – 3	0.3	0.952
<i>Total</i>	23.8	12.4	0 – 92	11.9	<0.001

Table 4 Least-squares means for the number of cattle by location and farming system

Variables	Peri-urban areas		Urban areas		Root MSE	$P_{l \times fs}^{1)}$
	Livestock farming	Crop-livestock farming	Livestock farming	Crop-livestock farming		
Cattle total	6.5 ^a	9.6 ^b	9.7 ^b	34 ^c	7.9	<0.001
Cows - local	0.4 ^a	1.7 ^b	0.2 ^a	0 ^a	1.6	0.041
- cross	2.2 ^a	1.6 ^a	3.9 ^a	18.0 ^b	3.7	<0.001
Oxen	0.2 ^a	1.7 ^b	0.2 ^a	1.8 ^b	1.2	0.931
Bulls	0.4 ^a	1.1 ^b	0.5 ^a	1.0 ^b	1.2	0.678
Heifers	1.5 ^a	1.5 ^a	2.3 ^a	7.0 ^b	2.2	<0.001
Calves	1.6 ^a	1.9 ^a	2.4 ^a	6.2 ^b	1.7	<0.001

1) $P_{l \times fs}$ = P -value for the interaction between location and farming system

^{a-c} Means with different letter of suffix in the same row differ significantly.

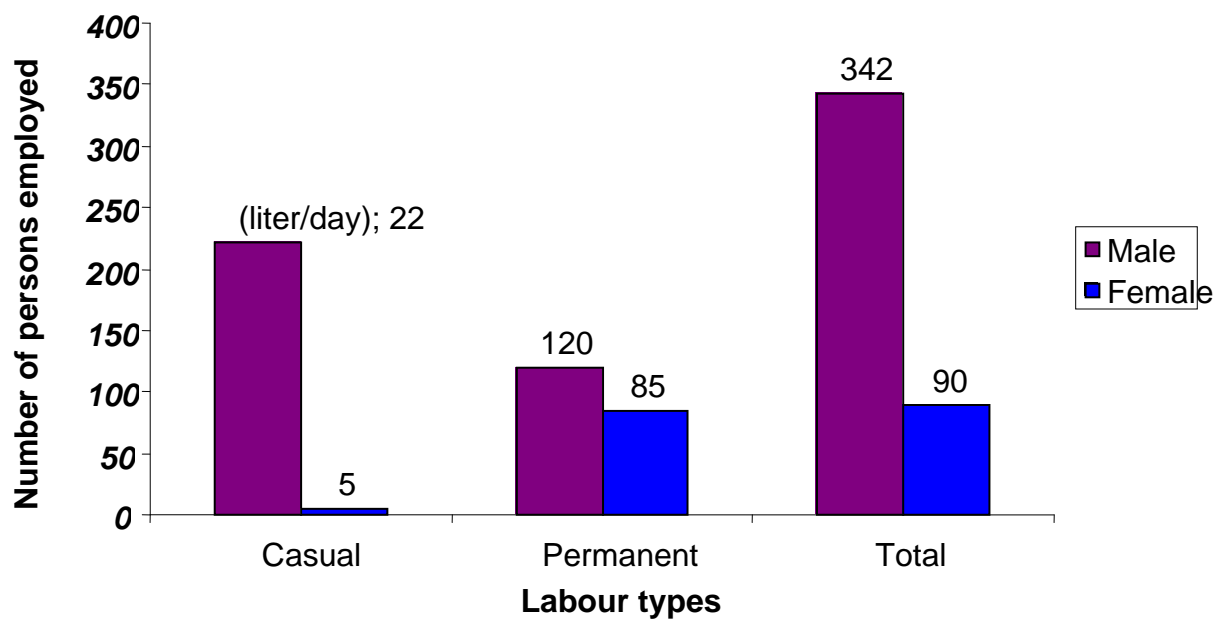
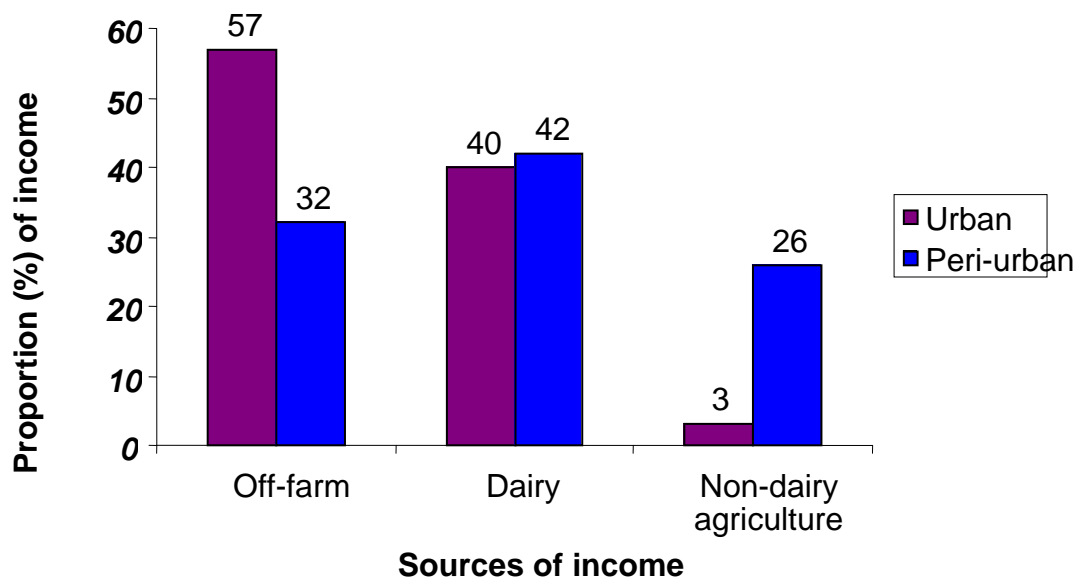
Fig. 1 Number of casual and permanently hired labourers of 256 dairy farms

Fig. 2 Proportion (%) of different income sources by location in 256 dairy farms



Chapter 3

Productive and reproductive performance of dairy cows in two important dairy production systems in the North western Ethiopian highlands

3. Productive and reproductive performance of dairy cows in two important dairy production systems in the North western Ethiopian highlands

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Key words: Dairy cows, Ethiopia, milk yield, production system, reproduction

Abstract: In order to characterise the dairy production systems as well as the productive and reproductive performance of dairy cows in the North western Ethiopian highlands, a total of 256 and 54 dairy farms were used for survey and monitoring data collection, respectively. Based on breed, land size, feed and market accessibility, two major dairy production systems were identified: an urban, more specialized, and a peri-urban dairy production system. Urban farmers owned larger herds but farmed less land, and sold a greater proportion of the milk produced than peri-urban farmers, who processed relatively more milk. Purchased feed played a more important role for the feed supply of urban than peri-urban farms.

Crossbred cows had a significantly higher milk yield than local cows, with the differences between production systems being significant only at early and mid lactation. A significant breed effect was found for lactation length, age at first calving and calving interval. It is concluded that efficient heat detection and timely insemination, better health management, genetic improvement of local breeds by pure breeding and/or crossbreeding and supplementation of poor quality feed

resources are the key factors for improving productivity of dairy cows and thereby increasing family income from milk production.

Abbreviations

ADF	acid detergent fibre
ADL	acid detergent lignin
AFC	age at first calving
AOAC	Association of Official Analytical Chemists
CACC	Central Agricultural Census Commission
Ca	calcium
CI	calving interval
CP	crude protein
DM	dry matter
DoARD	Department of Agriculture and Rural Development
HL	herd life
IVOMD	In vitro organic matter digestibility
LL	lactation length
LS	least-squares
MSE	mean-square error
N	number of observations
N	nitrogen
n.e.	not estimated
NDF	neutral detergent fibre
NMSA	National Metrological Service Agency
NSC	number of services per conception
P	phosphorus
p	probability
SD	standard deviation
TLU	tropical livestock unit

3.1. Introduction

Ethiopia ranks first in Africa and tenth in the world with respect to its livestock population. Livestock production contributes 33% and 12% of the agricultural and total gross domestic product, respectively, and accounts for 12-15% of the total export earnings (Ayele et al., 2003). Nevertheless, the current contribution of the Ethiopian livestock sector is below its potential at both the national and household level (Berhanu et al., 2007). In order to upgrade the genetic potential of the indigenous Zebu cattle and subsequently to improve the dairy sector in Ethiopia, large-scale crossbreeding with improved exotic dairy breeds was introduced 36 years ago (Brännäng et al., 1980). However, the success of such programmes has been quite variable for different reasons. The performance of animals depends not only on their genetic merit but also on other factors such as feeding, health management and other environmental factors. Both production traits (like daily milk yield and lactation length) and reproductive traits (such as age at first calving and calving interval) are crucial factors determining the profitability of dairy production (Peters and Ball, 1995; Lobago et al., 2007). The success of dairy production in general and crossbreeding programmes in particular needs to be monitored regularly by assessing the productive and reproductive performance under the existing management system in different agro-ecological zones.

In tropical and subtropical countries, market-oriented commercial large-scale and small-scale urban and peri-urban dairying has emerged as a result of the fast growing urbanization that accelerates the demand for food in general and for protein in particular. Furthermore, increasing income strata among urban people, a depressed economic situation with the subsequent inability to import dairy products and dwindling food aid have contributed to this development. In less developed countries of the tropics and subtropics in general and in Ethiopia in particular, urban and peri-urban dairying constitutes an important sub-sector of agricultural production. It plays a vital role in the lives of the urban and peri-urban poor by providing a source of subsistence through household nutrition, supplementary income and by generating employment opportunities for unemployed urban and peri-urban people (Azage and Alemu, 1998).

However, information is limited about the productive and reproductive performance of dairy cows in subsistence smallholder urban and peri-urban dairy farms in the tropics, particularly in

Ethiopia (Lobago et al., 2007). To fill these gaps, a conceptual framework for research in dairying was developed by relevant research institutes (ILRI, International Livestock Research Institute and EARO, Ethiopian Agricultural Research Organization). This shall provide a common basis for characterising and documenting dairy systems for further development interventions in the dairy sector (Rey et al., 1993). Since then, attempts have been made to characterise the dairy supply chains with particular emphasis to productive performance in the Addis Ababa area (Central Ethiopia). However, information is lacking on productive and reproductive performance and interacting factors of the smallholder dairy production systems in the North western Ethiopian highlands. Therefore, the objective of this investigation was to assess the most important dairy production systems, the productive and reproductive performance and to analyse interacting factors in these milk shed areas.

3.2. Materials and Methods

3.2.1. Study area

The study was conducted in two milk shed areas of the North western Ethiopian highlands, Bahir Dar and Gondar. The area lies on an elevated plateau ranging from 1720 to 3000 m above sea level. The average annual temperature and rainfall range from 10 to 30 °C and from 1000 to 1500 mm, respectively (NMSA, 2008). The study sites comprise 17 administrative districts (Bahir Dar, Bahir Dar Zuria, Achefer, Merawi, Dangla, Banja, Fagta, Fogera, Libo Kemkem, Farta, Debre Tabor, Gondar, Gondar Zuria, Dembia, Wogera, Dabat and Debark). According to the CACC (2003a) report, the urban (including zonal and district towns) and rural areas of these districts were estimated to comprise about 2.28 and 0.09 million households, respectively. The total population of the study sites was 11.9 million, while the total number of milking cows was about 387,000 (374,000 and 13,000 for rural and urban areas, respectively). The calculated average size of land per household which was assigned to the production of annual crops, perennial crops, for grazing and other purposes was about 0.99, 0.02, 0.18 and 0.07 hectare, respectively (CACC, 2003b).

3.2.2. Data collection

Data were collected utilizing three types of tools: rapid survey, questionnaire-based survey and monitoring. In 19 districts a rapid survey was conducted in order to estimate the total number of

dairy farmers keeping crossbred cows. Based on the information available from DoARD at district level, 15% (256) of the total dairy farmers keeping crossbred cows was selected for questionnaire-based survey data collection. Out of these 256 farmers, 54 farms were further observed using a monitoring tool as described below.

During the questionnaire-based survey, information was collected about farm size, farming system, herd size and composition, feeds and feeding systems, other characteristics of herd management, data about productive and reproductive performance, market access and input services. The chemical composition was analysed for the most commonly used feedstuffs, excluding feed components which were utilized on less than 10% of the farms (Table 1 and 2).

In the monitoring section of the study, pasture yield, nutritive value of feedstuffs utilized and daily milk yield at different stages of lactation were recorded. For the monitoring of farms, the year was divided into 3 seasons, depending on the amount of rainfall and temperature distribution (NMSA, 2008): high rainy season (June to September), dry season (October to February) and low rainy season (March to May). For estimation of the dry matter (DM) yield of the natural pastures, three sites were selected which were located at different altitudes (1700, 2200 and 3000 m above sea level). On each site a main plot with an area of about 81m² was fenced. Each main plot had three sub-plots of three replicates of 2 by 2 meters each. All the plants within these replicates were cut at ground level. Samples of the same season were pooled and weighed and a sub-sample was taken for analysis. Samples from crop residues and concentrates were collected at time of harvest and directly at the dairy farms, respectively. Since information about the chemical composition was available from literature (Anindo et al., 1994), chemical analysis was not performed for the improved forages present on the farms studied.

All samples were dried in an oven at 60 °C for 72 hours and ground in a Willey mill to pass through a 1mm sieve and were equilibrated to room temperature for 24 hours. The samples were then put in plastic bags until analysed for chemical composition. DM and ash content was determined following the AOAC (1995) methods. ADF and lignin were analysed following the method suggested by Goering and Van Soest (1970). Calcium (Ca) content was determined by use of atomic absorption spectrophotometer (Perkins, 1982) and auto analyser was used for determination of phosphorus (P; AOAC, 1995). For nitrogen (N) analysis, the Kjeldhal method was employed and crude protein (CP) content was estimated from the N content by use of a

multiplier of 6.25 (AOAC, 1995). *In vitro* organic matter digestibility (IVOMD) was done by the modified Tilley and Terry method as outlined by Goering and Van Soest (1970).

3.2.3. Data Analysis

To calculate the average number of dairy cows per farm, numbers were converted into tropical livestock units (TLU). The factors used for conversion of the numbers of local and crossbred cows into TLU were 0.8 and 1.2, respectively (Gryseels, 1988; Abdinasir, 2000). Data were analysed using the General Linear Model (GLM) procedures of the Statistical Analysis System (SAS, 2002). For most of the dependent variables of questionnaire-based data such as cow number, total daily milk yield per cow (excluding the milk directly consumed by the calf), lactation length (the time interval in months between the time of calving and dry off), age at first calving (number of months from birth to the animals first calving), calving interval (the period in months between two consecutive calving), herd life (the period in years from birth till culling) and number of services per conception, the independent variables production system (urban and peri-urban dairy production systems) and breed (local and local x Holstein Friesian crosses) were included into the model as fixed factors (Model 1 as given below). Interactions between factors were removed from the model if they did not show a significant ($p < 0.05$) effect, following a step-down procedure. For monitoring data, season and stage of lactation were included as additional fixed factors (Model 2 as given below).

$$\text{Model 1: } Y_{ijk} = \mu + P_i + B_j + (PB)_{ij} + \varepsilon_{ijk}$$

where Y_{ijk} is the value of the appropriate trait considered, μ common mean, P_i fixed effect of the i^{th} production system (i = urban and peri-urban), B_j fixed effect of j^{th} breed group (k = local and local x Holstein Friesian crosses), $(PB)_{ij}$ the interaction effect of i^{th} production system and j^{th} breed group and ε_{ijk} is the random error.

$$\text{Model 2: } Y_{ijkl} = \mu + P_i + S_j + B_k + L_l + \varepsilon_{ijkl}$$

where the additional factors are S_j , fixed effect of j^{th} season (j = dry, low and high rainy season), B_k fixed effect of k^{th} breed group (k = local and local x Holstein Friesian crosses), L_l fixed effect of l^{th} stage of lactation (l = early, mid and late) and ε_{ijkl} is the random error.

Moreover, a one-way analysis of variance was performed to test differences between seasons of the chemical composition of natural pastures. Differences between means were separated using the Duncan multiple range test (Steel and Torrie, 1960).

Chi-square-test was used to determine differences in the frequency of traits given as ordinal data. The differences between different levels of factors were analysed utilizing the Bonferroni-Holm test procedure (Ebl, 1987). For all statistical analysis, the level of significance was set at 0.05.

3.3. Results

3.3.1. Characterisation of the dairy production systems

Based on breed, land size, feed and market accessibility, two major dairy production systems were identified: an urban dairy production system, mainly (90%) consisting of specialized dairy farms, and a peri-urban dairy production system, mainly (58%) composed of mixed crop-livestock farms.

The urban dairy production system was found in the two major cities of the study areas, Bahir Dar and Gondar. 77, 14 and 5% of the 57 farms evaluated can be characterised as small (1 to 5 cows), medium (6 to 10 cows) and large (11 to 60 cows) dairy farms, respectively. The urban dairy production system is characterised by a market-oriented type of production and is mainly based on the use of crossbred animals (94%). These farmers on average own about 11 and 0.1 TLU of crossbred and local (Zebu type) cows, respectively. Excluding the amount of milk directly suckled by the calf, crossbred cows were estimated to produce on average 2614 litres of milk in a lactation period of 315 days. Of the total milk produced in the urban system, it was estimated that 47, 31, 7 and 15% was sold, used for home consumption, bucket-fed to the calf and processed into butter and cottage cheese, respectively. In peri-urban areas, the corresponding numbers were 21, 38, 4 and 37%, respectively. A comparison of the two systems showed that the proportion of milk sold was significantly higher in the urban system, while the proportion of milk processed was significantly higher in the peri-urban dairy system. The mean farm size was significantly ($p < 0.001$) lower (0.6 ha) for the urban than for the peri-urban system, for which it was estimated to be about 2 ha.

A peri-urban dairy production system was identified mainly within secondary towns and outskirts of secondary towns and cities. As compared to the urban dairy production system, more local cows were used in the peri-urban system (38 versus 6%). The average number (TLU) of crossbred and local cows per farm was about 1.9 and 1, respectively. The system mainly includes small (96.5%) and only a few medium (3%) and large (0.5%) scale dairy farms. Based on average daily milk yield and lactation length, it was estimated that a crossbred cow typically produced 2299 litres of milk in a lactation period of 315 days within this system.

3.3.2. Feed resources utilized in milk production

Grazing

In the peri-urban dairy production system, significantly ($p < 0.001$) more farmers had private grazing land as compared to urban dairy farmers (47 versus 14%). The grazing management varied with different breeds of milking cows and dairy production systems. In the majority (85%) of peri-urban dairy farms, local cows grazed freely for about 10 hours a day, while in the urban dairy production system, free grazing (for an average of 5.6 hours a day) was only practiced by 12.3% of the farmers. On the other hand, crossbred cows were rarely subjected to open grazing in the urban dairy production system (12.3%), which was significantly ($p < 0.01$) less than the 41.5% observed for the peri-urban dairy production system. Farmers preferred a cut-and-carry system for crossbred cows instead. Crossbred cows were also grazed significantly ($p < 0.01$) shorter than local cows (on average about 3 hours and 5.5 hours in the urban and peri-urban dairy production systems, respectively). Tethered grazing on roadsides and borders of farmland plots was not common in either production system.

Feedstuffs and their nutritive value

In the urban dairy production system, natural pasture or hay, concentrates, non-conventional feed like *Atella* (by-product from the production of local beer) and crop residues were identified as major sources of feeds in decreasing order of importance. All farmers used hay which was followed by concentrates; 96.5, 42 and 31.6% of the urban dairy farmers utilized noug (*Guizotia abyssinica*) cake, industrial brewery by-products, and wheat bran, respectively. On the other hand, *Atella* and crop residue (finger millet straw) were available for 42 and 26% of urban dairy producers, respectively. Most urban dairy farmers used purchased hay (98%) and concentrates (95%) from different sources.

Contrary to the urban dairy production systems, the majority of feedstuffs were home-grown on peri-urban farms. Only concentrates and hay were purchased by 88 and 13% of the farms, respectively. In decreasing order of importance, 100, 91, 55.3, 50 and 31% of these farmers utilized hay, industrial brewery by-product, *Atella*, crop residues and improved forages. In contrast to the urban producers, 50 and 31.6% of the peri-urban farmers used teff-straw and barley straw, respectively; additionally, the improved forages *Sesbania sesban*, Napier grass (*Pennisetum purpureum*), grass pea (*Lathyrus sativus*) and oats (*Avena sativa*) were also utilized.

The chemical composition and nutritive value of natural grazing pasture and of the most common feed sources (such as crop residues, concentrates, improved forages and *Atella*) are presented in Table 1 and Table 2, respectively. Season had a significant ($p < 0.01$) effect on ash and ADF content of the natural pasture. While the seasonal influence on NDF percentage and IVOMD of the natural pasture was significant ($p < 0.05$), it did not significantly ($p > 0.05$) affect CP, Ca, P and ADL content.

3.3.3. Productive and reproductive performance

The least-square means for factors affecting the estimated daily milk yield at early (months 1 to 3), mid (months 4 to 6) and late (months 7 and above) lactation are presented in Table 3 for the different dairy production systems and breeds.

From the survey data, the total average daily milk yield excluding the amount of milk directly suckled by the calf of local and Friesian x local cows was 2.8 ± 0.47 and 7.8 ± 0.19 litres per cow, respectively. Very similar results were obtained from the monitoring data, from which it was estimated that local cows yield 3.4 ± 0.56 and crossbred cows yield 7.7 ± 0.23 litres per day. Least-squares means analysis of both data sets (survey and monitoring) showed that the breed of dairy cows significantly ($P < 0.001$) affected the estimated daily milk yield. The monitoring data revealed the significant ($p < 0.001$) effect on daily milk yield at all stages of lactation, while the differences between production systems showed a significant ($p < 0.01$) effect only at early and mid lactation. From the survey data, no significant ($p > 0.05$) difference was observed in daily milk yield of cows between the two production systems. Similar results were observed on the daily milk yield of local cows (2.9 and 2.6 litres in the urban and the peri-urban system,

respectively) as well as crossbred cows (8.3 and 7.3 litres in urban and peri-urban system, respectively). No interaction effects for the fixed factors breed, season, stage of lactation and production system were observed. The monitoring data collected at different times of a year indicated that season had no significant ($p>0.05$) effect on the cows' average daily milk. Frequency of milking had a highly significant ($P<0.001$) effect on daily milk yield of crossbred cows with an increase from 7.3 ± 0.25 litres per cow per day if milked twice to 9.9 ± 0.48 litres per cow per day for milking three times.

Lactation length (LL) was not significantly ($p>0.05$) different between production systems. However, breed showed significant ($p<0.05$) differences in LL, with local cows being in milk for one month longer than crossbred cows (Table 4).

Of the total (256) dairy producers interviewed, 83.8% of the farmers milked their cows twice a day, while fewer farmers (16.2%) milked their cows thrice a day. All dairy producers used partial suckling (calf suckling their dam for a few minutes before and after milking) for local cows. For crossbred cows, the majority (60.6%) of the dairy producers used partial suckling before and after milking, and another 6.7% practiced partial suckling before milking only. Almost one third (32.7%) of the farmers did not allow the calves to suckle their mothers. The higher the exotic blood level, the more frequently this practice was found: milking without suckling was practiced by 21.7, 23.2 and 45.5% for farms keeping crossbred cows of the types $<50\%$ Holstein Friesian, F_1 , and F_2 and above Friesian blood level, respectively.

The least-squares means results for factors affecting age at first calving (AFC), calving interval (CI), number of services per conception (NSC) and herd life (HL) are presented in Table 5. AFC and CI were significantly ($p<0.01$) affected by breed of dairy cows, while the production system did not show a significant ($p>0.05$) effect. Estimates for NSC was neither significantly ($p>0.05$) different for the different genetic groups of cows nor for the two dairy production systems (Table 5). Similarly, the effects of production system and genetic group showed no significant effect on HL (12.6 ± 0.43 and 13.4 ± 0.23 years for urban and peri-urban system, respectively; 13.4 ± 0.31 and 12.6 ± 0.33 years for local and crossbred cows, respectively; Table 5).

3.4. Discussion

The aim of this study was to characterise the different dairy production systems found in the North western Ethiopian highlands, to estimate the productive and reproductive performance and to analyse some important factors which influence the performance.

Characterisation of dairy production systems

Based on breed, land size, feed and market accessibility, two dairy production systems were identified: an urban, specialized system and a peri-urban, mixed crop-livestock system. By using similar criteria, Sere and Steinfield (1995) and Sintayehu et al. (2008) characterised and differentiated cattle production systems. Like in other tropical regions, the urban dairy production system described herein, can be characterised by the type of inputs, particularly feeds and breeds of cattle: feedstuffs used were predominantly purchased concentrates and roughages (mainly hay), while in the peri-urban dairy production systems most feed sources were produced on-farm, mainly crop residues and hay. This observation is in agreement with previous studies conducted in the tropics (Sintayehu et al., 2008).

The estimates for number of cows per farm reported herein showed that a significantly higher proportion of crossbred cows were found in the urban than in the peri-urban dairy production system. The current study revealed that a greater proportion of urban than of peri-urban dairy farmers had access to the market for fresh milk sale (47 *versus* 21%, respectively). This might have encouraged urban farmers to keep more crossbred cows than peri-urban farmers. For the purpose of supplying draught power for crop production in the peri-urban dairy production system, farmers were interested to keep more non-dairy cattle which might have resulted in the greater number of local cows there. A similar conclusion was given by Yoseph et al. (2003) and Sintayehu et al. (2008) who analysed similar cases in the Ethiopian highlands.

The proportion of milk sale was significantly higher in the urban than in the peri-urban system, while for the proportion of milk processed the opposite was true. In urban farms, a similarly high proportion of milk sale as compared to processing was reported in a previous study (73 and 7.6%, respectively; Mohamed et al, 2003). In the urban system, the high proportion of milk sale is

fostered by the growing urbanization which increases the demand for protein in the cities (Azage and Alemu, 1998).

Nutritive value of feedstuffs

In the current study, the overall CP content of the natural pasture (Table 2) is comparable with the range of 3.2 to 9.8% (on DM-basis) from an earlier research report (Kavana et al., 2007) covering tropical conditions. The current estimates for the CP content of natural pasture in the dry and low rainy season was typical for most matured tropical grasses and was observed to be lower than the forage CP content of about 7% which would likely cover the maintenance requirement of ruminants (McDonald et al., 1995). Since the IVOMD of these pastures is low, the dairy cows depending on such feed will not express their full genetic potential which is probably one of the reasons for the low daily milk yield and extended AFC and CI of cows (Table 4 and 5). This is supported by the work of McDonald et al. (1995) who reported that feed resources with an apparent digestibility of organic matter of 42-45%, 60%, and 70% and above resulted in minimum, medium and high performance of ruminants, respectively. One of the challenges of growing forage in tropical environments is the effect of environment on the nutritional characteristics of plants (Aganga and Tshwenyane, 2003). In this study, the exposure of fodder plants to high ambient temperature might have resulted in low CP and high lignin contents and hence a low digestibility. This is in agreement with the remark of Agana and Tshwenyane (2003) who stated that high temperature decreased the soluble carbohydrate content of plants, resulting in increased fibre content and decreased digestibility. The Ca and P content observed for natural pastures may satisfy the dietary requirement of grazing animals (0.2-0.4 and 0.1-0.15% for Ca and P, respectively; Kabaija and Little, 1988).

The CP content of teff straw (Table 3) is comparable with values reported by Lulseged and Jemal (1989), while the CP content of wheat and barley straw is comparable with those given by Alemayehu (1999) who studied feed resources in the Southern Ethiopian highlands. Except grass pea straw, all other crop residues (Table 2) showed a low CP content which is probably insufficient to cover just the maintenance requirement of ruminants. This is in agreement with most research reports covering the tropics (Adugna, 1990; McDonald et al., 1995; Esubalew, 2002). The low nitrogen content of most crop residues is likely to result in reduced microbial proliferation and therefore low rumen fermentation rate which may in turn depress feed intake (Van Soest, 1994). The digestibility of forages is affected by its degree of maturity (Aganga and

Tshwenyane, 2003). Lignin concentration increases with the age of forage (Aganga and Tshwenyane, 2003), resulting in low organic matter digestibility of plants (Karachi, 1998; Aganga and Tshwenyane, 2003). Therefore, the low IVOMD of crop residues, which were harvested after maturation of the plants and the removal of grains, was mainly caused by their high lignin content. Similarly, McDonald et al. (1995) reported that crop residues are deficient and unbalanced in their mineral composition which is in agreement with the current results. Most crop residues studied showed Ca and P contents which were too low to cover the maintenance requirement of ruminants. Studies published by Haque et al. (1993) and Greene (2000) point to the chemical characteristics of the soil being a major factor affecting the contents of essential minerals in forage.

Concentrates, as compared with natural pastures and crop residues, on average showed higher CP, Ca and P contents (Table 2) which should be sufficient to cover at least the maintenance requirement of ruminants as reported by Kabaija and Little (1988) and McDonald et al. (1995). Concentrates (wheat bran, noug seed cake and industrial brewery by-products) had higher IVOMD values which may help to satisfy the ruminants' requirements and thereby to express their full genetic potential for production and reproduction. The estimated total IVOMD content of *Atella* and brewery by-product were lower than that of wheat bran and noug seed cake (Table 2), which was probably due to their relatively high lignin content. A similar conclusion was drawn by Demeke (2007).

Concerning their CP content, concentrates and improved forages were mostly superior to crop residues and natural pastures. Therefore, concentrates and improved forages can be strategically used as a protein supplement in dairy farms where poor quality crop residues and natural grazing pastures are dominant.

Performance of dairy cows

In this study, breed had a significant effect on daily milk yield of cows (Table 3). This is in agreement with previous reports (Kiwuwa et al., 1983; Abdinasir, 2000; Kelay, 2002) from Ethiopia in which it was shown that indigenous Zebu breeds had a significantly lower milk yield than their crosses with Holstein Friesian. A similar result (7.2 litres/day) was reported by Das et al. (1999) for crossbred cows. On the contrary, the present finding of 3.4 litres a day for local cows is lower than the values from the latter report (6.1 litres/day). This might be due to less

attention given by farmers to local cows. Season showed no effect on milk yield at all stages of lactation; the major reason for this is probably feed conservation which helps to minimize variation in feed availability. In the urban dairy production system the overall average daily milk was higher than in the peri-urban dairy production system. This superiority is in agreement with results from Shiferaw et al. (2003) who concluded that the availability of feed resources and efficient nutritional and herd health management were principal constraints in all dairy production systems and especially in peri-urban dairy production systems. Therefore, the relatively better management in urban dairy production may be considered as key factor for the better performance as compared to peri-urban dairy production.

The overall mean lactation length of crossbred cows estimated in this study (Table 4) lies within the range of 9.3 to 17.5 months as given by Teodoro and Madalena (2003), Msangi et al. (2005) and Lobago et al. (2007). Lactation length of local cows was significantly longer by one month (Table 4) and was very similar to the 11.8 months (Goshu, 1981 cited from Kelay, 2002). The shorter lactation length of crossbred cows is associated with their shorter CI. This view is supported by (Syrstad, 1985 cited from Kelay, 2002) who suggested that, if a cow does not dry off naturally, it is usually forced dry five to six weeks before the expected calving date in order to provide a sufficient rest prior to the ensuing lactation. Length of lactation, therefore, is determined by length of the calving interval.

Local cows had higher AFC and longer CI than crossbred cows (Table 4). This is supported by several research reports from Ethiopia which revealed that the minimum AFC was 29.1 months for F₁ Friesian-Zebu cows (Albero, 1983) and the maximum was 53.0 months for pure zebu cows (Mukasa-Mugerwa et al., 1991). Similarly, Gebeyehu et al. (2005) showed that F₁ Friesian-Fogera crosses had a lower age at first service (36.8 ± 0.8 months) than pure Fogera heifers (45.4 ± 1.2 months), indicating that crossbred heifers reach puberty earlier than the purebred local heifers. The estimates for CI of Zebu cows from this study are within the range of 12.2 to 26.6 months that was reported by Mukasa-Mugerwa et al. (1991). CI of crossbred cows (Table 4) was slightly lower than that reported by Shiferaw et al. (2003). However, in this study, for both breeds the economically important traits AFC and CI were substantially beyond the minimum values reported in the available literature. These points to the potential benefits of improved management and environmental conditions.

The lacking difference in NSC between breeds observed here is in agreement with Rahman et al. (1998) who reported that NSC was not significantly different between breeds. Nevertheless, the current results for both breeds are higher than reported for tropical conditions (1.3 and 1.7 for crossbred and local cows, respectively; Rahman et al. 1998). Such differences might be partially attributed to differences in the rearing system (Das et al., 1999), especially the quality of feeding and breeding management. The mean herd life (HL) for both breeds (13.4 ± 0.31 and 12.6 ± 0.33 years for local and crossbred cows, respectively) observed in the current study is in agreement with a report by Gebeyehu et al. (2007) who analysed similar cases in the Ethiopian highlands and found an average of 13.2 ± 0.30 years. On the contrary, substantially lower values of 9 to 10 years were reported by Farm-Africa (2006) for both breeds in the southern part of Ethiopia. These differences might be at least partially attributed to the rare practice of voluntary culling (Gebeyehu et al., 2007). The higher HL, together with relatively late AFC, longer CI and low lactation milk yield reported herein emphasizes the need for improved health, feeding, breeding and culling management.

3.5. Conclusions

Urban and peri-urban dairy productions are important production systems in the highlands of North western Ethiopia, where they help to buffer the large difference between milk demand and supply. In order to improve the relatively low average daily milk yield, the extended AFC and CI, and the reduced lifetime milk production associated with these, efficient heat detection and timely insemination, better health management, genetic improvement of local breeds by pure breeding and/or crossbreeding, supplementing of poor quality feed resources (like crop residues and hay) are necessary. For urban dairy farmers, the lack of farm land to produce feed for dairy cows has to be overcome in order to reduce their dependence on purchased feed. Milk production based on crop residues and natural pasture can be increased when supplemented with feedstuffs with a higher CP content (such as concentrates and improved forages). However, no economical analysis of the utilization of more concentrates and improved forages was performed within the current study. Therefore, further studies shall focus on a cost-benefit analysis of the production and utilization of greater quantities of concentrates and/or improved forages and the identification of alternative feed resources in order to improve milk production and increase income from this activity.

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Table 1 Seasonal variation in nutritive value of native grazing pastures in the North western Ethiopian highlands.

Season	Nutrient content in % of DM and digestibility (%) \pm SD							
	CP	NDF	ADF	ADL	IVOMD	Ash	Ca	P
Dry	4.4 \pm 1.52 ^a	75.5 \pm 1.58 ^a	47.5 \pm 4.70 ^a	7.2 \pm 2.89 ^a	55.8 \pm 3.30 ^a	9.6 \pm 1.53 ^a	0.7 \pm 0.36 ^a	0.16 \pm 0.09 ^a
Low rainy	3.5 \pm 1.19 ^a	76.7 \pm 3.53 ^a	47.9 \pm 2.67 ^a	6.5 \pm 2.15 ^{ab}	54.0 \pm 8.94 ^a	8.8 \pm 1.53 ^a	0.6 \pm 0.29 ^a	0.15 \pm 0.09 ^a
High rainy	10.2 \pm 5.44 ^a	67.8 \pm 3.78 ^b	38.1 \pm 4.86 ^b	5.0 \pm 1.93 ^b	71.2 \pm 14.70 ^b	14.5 \pm 1.53 ^b	0.6 \pm 0.17 ^a	0.22 \pm 0.10 ^a
Mean	6.0	73.3	44.5	6.2	60.4	11.0	0.6	0.2
P values for the effect of season	0.133	0.029	0.010	0.058	0.040	0.004	0.491	0.494

Means with the same letter of suffix in the same column did not differ significantly ($P \geq 0.05$), *SD* = Standard deviation

CP = crude protein, *NDF* = neutral detergent fibre, *ADF* = acid detergent fibre, *IVOMD* = in vitro organic matter digestibility, *Ca* = calcium, *P* = phosphorus, *DM* = dry matter

Table 2 Nutritive value of hay, crop residues, concentrates and improved forages in the North western Ethiopian highlands.

		Nutrient content in % of DM and digestibility (%)							
		CP	NDF	ADF	ADL	IVOMD	Ash	Ca	P
Crop	Grass pea (<i>Lathyrus sativus</i>) straw	9.6	64.85	53.2	10.1	56.9	8.8	1.1	0.1
residues	Teff straw	5.4	74.7	45.5	5.7	56.3	11.0	0.4	0.2
	Wheat straw	2.4	73.1	51.5	6.8	45.4	16.8	0.3	n.e.
	Barley straw	3.4	80.5	50.9	5.1	48.6	7.6	n.e.	0.1
Concentrates	Wheat bran	14.6	40.2	11.8	2.8	86.5	4.8	0.2	0.9
	Noug seed cake	32.9	36.6	30.3	12.1	72.7	8.0	0.7	0.9
	Industrial brewery by-product	27.6	75.0	23.1	5.2	64.6	6.3	0.1	0.7
Improved forages	<i>Sesbania sesban</i>	20.2	19.8	10.7	2.6	n.e.	n.e.	n.e.	n.e.
	Vetch (<i>Vicia dasycarpa</i>)	22.4	44.3	34.4	5.5	67.4	n.e.	1.0	0.4
	Oats (<i>Avena sativa</i>)	8.1	54.5	37.1	3.5	65.5	n.e.	n.e.	n.e.
	Napier Grass (<i>Pennisetum purpureum</i>)	6.3	64.5	41.1	5.5	65.0	n.e.	0.3	0.4
Non-conventional	Atella (Local brewery by-product)	22.4	57.7	25.5	11.9	63.5	2.8	0.3	0.3

CP = crude protein, NDF = neutral detergent fibre, ADF = acid detergent fibre, IVOMD = in vitro organic matter digestibility, Ca = calcium, P = phosphorus, DM = dry matter and n.e. = not estimated.

Table 3 Daily milk yield (litre/head) of cows by stage of lactation, dairy production system and breed in the 54 monitored farms of North western Ethiopian highlands (LS-means; Root MSE = 3.41)

Stage of lactation	Dairy production systems			Breed		
	Urban (N = 125)	Peri-urban (N = 144)	P _{System}	Local (N= 41)	Crossbred (N = 228)	P _{Breed}
Early	9.5	6.9	0.001	5.1	11.4	<0.001
Mid	6.8	5.0	0.002	3.6	8.2	<0.001
Late	3.1	2.9	0.184	1.8	4.6	<0.001

Table 4 Reproductive performances of cows by production system and breed in the 256 surveyed farms of North western Ethiopian highlands (LS-means)

Trait	Dairy production systems			Breed of cows			Root MSE
	Urban	Peri-urban	P _{System}	Local	Crossbred	P _{Breed}	
AFC (months)	46.0(70)*	43.3(299)	0.116	57.1(144)	32.2(225)	<0.001	10.64
CI (months)	18.5(69)	18.5(304)	0.949	23.1(140)	13.9(233)	<0.001	5.82
NSC (number)	1.9(66)	2.1(303)	0.745	2.0(139)	2.0(230)	0.578	0.91
HL (years)	12.6(34)	13.4(135)	0.123	13.3(107)	12.7(62)	0.088	2.53
LL (months)	11.2(74)	10.8(305)	0.634	11.5(143)	10.5(236)	0.043	4.68

AFC = age at first calving, CI = calving interval, NSC = number of services per conception, HL = herd life, LL = lactation length, RMSE = root mean square error.

**Numbers in brackets show the number of observations used for analysis*

Chapter 4

Milk handling, processing and marketing systems in the milk shed areas of North western Ethiopian highlands

4. Handling, processing and marketing of milk in two important production systems in the North western Ethiopian highlands

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Key words: Dairy, Ethiopia, marketing, milk, milk products, processing

Abstract: In order to describe the ways of handling, processing and marketing milk from urban and peri-urban production systems of the North western Ethiopian highlands, 256 and 54 dairy farms were selected for survey and monitoring data collection, respectively. Due to poor market access and high transaction costs and the perishable nature of raw milk, the amount of sold milk (products) and prices were significantly lower for peri-urban producers. Prices were also low during fasting periods and during the wet season; when milk production was reactively high. Traditional ways of milk processing at household level include practices which may contain risks for product quality or even human health. Providing basic handling and health education for producers therefore is likely to result in improved milk (product) quality on the markets. Direct delivery to the nearby consumers was the largest primary milk outlet for producers of both systems, while retailers and milk cooperatives were the second most common outlets for the urban and the peri-urban system, respectively. Therefore, to enhance dairy production and marketing, milk co-operatives that could be able to market larger volumes and sufficiently reduce transaction costs should be supported by governmental and non-governmental organisations through providing technical and infrastructural support.

Abbreviations

CACC	Central Agricultural Census Commission
DoARD	Department of Agriculture and Rural Development
ILCA	International Livestock Research Institute
ILDP	Integrated Livestock Development Project
NGO	Non-governmental Organizations
NMSA	National Metrological Service Agency

4. 1. Introduction

The economy of the Amhara region in particular and the nation in general is mainly dependent on agriculture, which in the 2004/05 fiscal year, contributed about 48% of the GDP, followed by 39% from the service sector, and 13% from the industrial sector. The agriculture sector provides employment for about 80% of the population (The Economist Intelligence Unit, 2007). Taking into account the huge Ethiopian livestock population, which is the greatest in Africa, the livestock sub-sector contributed less to the national economy than could be expected (Berhanu et al., 2007). The dairy industry in the country is constrained by several technical and economic factors (Fekadu, 1994) and the national milk production remains among the lowest in the world, even by African standards (Zegeye, 2003). One of the necessary conditions for increased milk production is the provision of assured marketing outlets that are sufficiently remunerative to producers. Experience from countries like Uganda and Kenya pointed to marketing outlet being a key initiator of milk production by smallholders. Besides the sale of fresh milk, processed milk products may be another option to support farmers' income. Dairy development planners should consider the relative efficiency of alternative milk marketing systems in terms of costs and marketing margins, product quality, range and stability of services offered and stability of producers and consumer prices (Sintayehu et al., 2008). However, from the point of view of policy makers, development agents and private investors, information about the potential of milk production, processing and marketing is lacking.

Urban and peri-urban dairy production systems involve production, processing and marketing of milk and milk products that are channelled to urban centres. It plays a vital role in the lives of the urban and peri-urban poor by providing a source of subsistence through household nutrition (milk and meat), supplementary income and generating employment opportunity. Although many efforts were made towards dairy development and various research projects have been undertaken in some parts of the country, the outcome and impact have not been satisfactory. Most development and research projects in dairying were conducted within and/or around the Addis Ababa milk shed (Sintayehu et al., 2008). Currently, dairy development projects such as ILDP (Integrated Livestock Development Project), IPMS (Improving Productivity and Market Success of Ethiopian farmers) and Land O'Lakes (USAID Dairy Development Program) have been launched in the areas addressed herein.

Although different sectors of the regional government offices have been also providing technical support for these and similar projects, no studies were conducted on the impact of all these projects on the dairy producers and the current status of processing and marketing the milk produced by smallholders. Therefore, the objective of this study was to explore the dairy processing and handling practices and to evaluate the ways of marketing in the urban and peri-urban dairy production systems of the North western Ethiopian highlands.

4. 2. Materials and Methods

4.2.1. Study areas and data collection

The study was conducted between July 2006 and March 2007 in order to characterize the milk handling, processing and ways of marketing of the urban and peri-urban dairy systems in the milk shed areas (Bahir Dar and Gondar) of North western Ethiopian highlands. The urban production system deals with primary dairy supply chains in the inner cities and major towns, while the peri-urban system includes farms found in the periphery of cities and secondary towns. The study sites comprise 17 administrative districts (Bahir Dar, Bahir Dar Zuria, Achefer, Merawi, Dangla, Banja, Fagta, Fogera, Libo Kemkem, Farta, Debre Tabor, Gondar, Gondar Zuria, Dembia, Wogera, Dabat and Debark). According to the CACC (2003a) report, the urban (including zonal and district towns) and rural areas of these districts were estimated to comprise about 2.28 and 0.09 million households, respectively. The total population size of the study sites was 11.9 million, while the total number of milking cows was about 387,000 (374,000 and 13,000 for rural and urban areas, respectively; CACC, 2003b). The study areas are located on an elevated plateau ranging from 1720 to 3000 m above sea level. The average annual temperature and rainfall range from 10 to 30 °C and from 1000 to 1500 mm, respectively (NMSA, 2008).

In a first step, a rapid survey was conducted at district level with the DoARD Offices in order to identify dairy farmers who keep different cattle breeds and represent different farming systems and milk production potentials in varying agro-ecological zones; information was collected from 19 districts. Based on this, a total of 256 dairy farmers (57 from urban and 199 from peri-urban areas), representing 17 districts, were chosen randomly. After a pre-test of the questionnaire, farmers were individually interviewed. The questionnaire consisted of open and closed questions, all of which were translated into the local language. It was designed in a

way to obtain information on milk production and utilization, including types of milk products, ways of handling, processing and marketing. Moreover, to verify survey information like the amount of milk production and utilization, 54 farmers out of 256 respondents were selected randomly and monitored once per season. For seasonal classification, the amount of rainfall and temperature distribution information from NMSA (2008) was used and the year was divided into two broad categories, the dry season (October to April) and the wet season (May to September). With the objective of evaluating the contribution of milk cooperatives/producers as option for market entry point for smallholder dairy farmers, a semi-structured questionnaire was also developed and information about the date of establishment, number of member farmers, capacity of buying, processing and selling of milk (products), number of milk collection sites they have and constraints were collected from a total of 13 milk cooperatives or producer groups found within 17 districts covered in the study areas.

4.2.2. Data analysis

Fixed factors such as dairy production system (urban and peri-urban) and season (wet and dry) were used as classification variables for most dependent variables such as amount of milk produced, milk sold, home consumed, bucket fed to calves and processed, shelf life (refers the interval between the time of production to possible period of stay being accepted by the end users) and the price of dairy products. Breed of cows (local *versus* local x Holstein Friesian) was also included as a fixed factor to estimate the effect on type and amount of milk utilisation. Preliminary analysis showed that interaction effects of the fixed factors were not significant and hence were excluded from the model. An attempt was made to evaluate the influence of sex of the household head, household size, farming system and religion of dairy farmers on the amount of milk production and utilisation. However, no significant effect was observed. Hence, these fixed factors were excluded from the model. Data were analysed using General Linear Model (GLM) procedures of the Statistical Analysis System (SAS, 2002).

Chi-square-test was used to determine differences in relative frequency of ordinal data. The differences between different levels of factors were analysed utilizing the Bonferroni-Holm test procedure (EBI, 1987). For all analysis, the level of significance was set at an alpha of 0.05.

4.3. Results

4.3.1. Milk production and utilization

In the study areas, the total annual milk produce was estimated to be about 1.4 million litres from 256 farms. By production system, it was about 0.6 and 0.8 million litres from 57 and 199 farms of urban and peri-urban dairy systems, respectively. To verify the information about the milk utilization collected during the survey (Fig.1ab), actual measurements were made of the amount of milk produced, sold, bucket fed to calves, home consumed and processed were done (Fig. 2ab).

The monitoring data revealed that significantly ($p<0.001$) more milk was produced by urban than by peri-urban farmers (43 and 14.1 litres litres/household/day, respectively; Fig. 2ab). From the survey data, a comparison of the two systems showed that the proportion of milk sold was significantly ($p<0.001$) higher in the urban system than peri-urban system (47% *versus* 21%), while the opposite was true for the proportion of milk processed (15% *versus* 25%; Fig.1ab). Similar results, but with an even greater difference between production systems, were obtained from the monitoring data (Fig. 2ab). Both in the monitored and the surveyed farms of the urban system, the amount of milk bucket-fed to calves was significantly higher than in the peri-urban farms (Fig. 1ab and 2ab). The survey data analysis showed that in the peri-urban farms a significantly ($p<0.05$) higher proportion of milk was consumed at home as compared to urban farms (51 versus 31%).

4.3.2. Handling of milking processing equipments

Surveyed dairy farmers were observed using different milk utensils for collecting, storing and processing milk. The majority (62%) of the peri-urban producers used gourd and the rest (48%) used clay pot utensils. Besides, few (10%) of the total peri-urban producers had access to the aluminium milk utensils. In urban farms more (83%) used plastic utensils and the rest (17%) used aluminium utensils. In addition to these, 33 and 21% of the urban farmers had access to use gourd and clay pot utensils.

In both production systems about 94 % of the farmers cleaned the udder before milking, 6.7% (urban) and 5% (peri-urban) producers did so before and after milking. While urban farmers equally used warm and cold water for this purpose, the majority of peri-urban farmers (68%)

used warm water. Except one farmer, all producers cleaned their milk utensils at least once a day. The predominant practice (73.4% of farmers) was the use of water and leaves of shrubs (such as *Combretum molle* (Abalo), *Ocimum suave* (Dama Kessie) and *Buddleja polystachia* (Anfar)) twice a day, followed by drying and smoking with plants specifically used for this purpose (e.g. *Rosa abyssinica* (Qega), *Osyris quadripartite* (Keret), *Otostegia integrifolia* (Tinjut), *Olean Africana* (Woirra), *Thymus vulgaris* (Tosgne) and *Juniperous procera* (Tid)). The sources of water which the farmers had access to, were significantly different for the two production systems: while almost all (94.7%) of the farmers had access to pipe water in the urban areas, water from bore wells (18.1%) and rivers (17.6%) was also used in the peri-urban locations.

4.3.3. Types, processing systems and shelf life of dairy products

The milk products produced in the study areas include fresh milk, yoghurt-like fermented/sour milk (Ergo), traditional butter (Kibe), traditional ghee (Neter Kibe), cottage cheese (Ayib), traditional hard cheese (Metata Ayib), buttermilk (Arrera), and whey (Aguat). The typical processing scheme for these products is shown in Fig. 3. Churning was observed in 58% of the surveyed urban households. 42% of these were involved in further processing of buttermilk into cottage cheese and whey. Churning and subsequent production of cottage cheese and whey from butter milk were even more frequent in the households of peri-urban producers (73.4% and 52.8%, respectively).

Fresh milk

Results of the survey showed that the milk producers used different techniques to preserve fresh milk without clotting, such as smoking of the container and boiling of fresh milk before collection, or refrigeration. In both production systems, smoking was the predominant practice, performed by 54 and 62.4% of urban and peri-urban producers, respectively. 16% of the urban farmers used a refrigerator, an option which was almost not present in the peri-urban areas. Cooling by putting the container with milk into a cold-water bath was practiced by about 4.8 % of the peri-urban producers. The average shelf life of milk and milk products showed no significant ($p>0.05$) difference between the production systems.

Fermented/sour milk (Ergo)

21% of the milk produced was consumed fresh or allowed to ferment naturally. The product typically was semi-solid and in smallholder dairy farms it was produced from whole milk,

while in milk cooperatives or other producer groups it was produced from skim milk. On average, milk was accumulated in a clay pot or a gourd over a period of 1 to 4 days and allowed to develop acidity. The mean shelf life of fermented milk was 3.8 days. According to the information collected from the respondent farmers, fermented milk was the main product used as basis for further processing of various fermented milk products such as traditional butter, ghee, cottage cheese, butter milk and whey (Fig. 3).

Traditional butter (Kibe)

The proportion of interviewed farmers using different means of preservation for traditional butter and cottage cheese is depicted in Table 1. All surveyed producers, except one NGO-farm, produced traditional butter from fermented whole milk, but not from cream. The traditional churning utensils were on average filled with about 11 litres of fermented milk, followed by agitation with a wooden stick to break the curd before churning. After this, the churning device was typically covered with a piece of skin or leather which was stretched over the mouth and was securely tied. The final point of the churning process was detected by a sequence of indicators, such as observing the sound of the churned milk and the visual judgement of the surface of a piece of straw inserted into the churn. The butter was then kneaded in cold water and washed to remove visible residual buttermilk (*Arerra*). The average churning time reported was about 3.5 hours. According to the information from the interviewed farmers, the relative amount of whole milk converted into butter and cottage cheese was about 4.3 and 16%, respectively.

Buttermilk (Arerra)

As described above, buttermilk is a by-product of the formation of butter from fermented milk. At household level, part of this by-product was reported to be consumed by the household members and by suckler calves. The rest was processed in to cottage cheese.

Cottage cheese (Ayib)

Cottage cheese is a soft curd-type cheese made by the churning of buttermilk mainly at household level, while in one farm and in milk cooperatives or other producer groups it was produced from skim milk. Cottage cheese was prepared by heating the buttermilk in an iron or clay pot until a curd-mass formed; this was followed by cooling to coagulate the curd. Then, the curd was separated from the whey through a fine-meshed cloth or a sieve. It was observed that about a kilogram of cottage cheese could be obtained from about 11 litres of buttermilk or skim milk. Part of the cottage cheese was further processed into traditional hard cheese (*Metata Ayib*). Putting the cottage cheese in a sieve container and squeezing was done in

intervals for about 3 days until the water content was sufficiently reduced. After the cheese was drained sufficiently and became dry enough, spices were added to give a desirable flavour. The spices mainly used were the aerial parts of *Ruta chalepensis* (Tena Adam) and *Ocimum basilicum* (Beso Bila), the rhizomes of *Zingiber officinalis* (Zigibl), Turmeric (Erd) *Allium sativum* (Netch Shinkurt), red shallots (Key Shinkurt) and the seeds of *Aframomum corrorima* (Corerima). The traditional hard cheese was reported to be able to store averagely about 2.1 years before consumption with out losing its desired flavour and taste by the local consumers.

Traditional ghee (Neter Kibe)

Traditional ghee was made by evaporation of the water from butter by heating and melting of butter in an iron or clay container until bubbling ceases. The ghee was decanted into another container leaving the curd material in the pan. The procedure and plants used therein to spice ghee for flavour and preservation purposes were similar as described for traditional hard cheese above. The consistence of this product was described as semisolid at room temperature. It could be stored for about 2.8 years without losing the quality desired by the local consumers.

4.3.4. Marketable dairy products and price determinants

The dairy products most commonly marketed by smallholder dairy farmers were raw whole milk and traditional butter or ghee. Furthermore, 100, 33, 89 and 78% of the milk cooperatives and other producer groups were selling traditional butter, cheese, skim milk and yoghurt, respectively. The average amount of milk and milk products sold per milk cooperative or other producer group is shown in Fig. 4. At the time of data collection, a new milk processing plant was established which in the initial stage daily processed 1500 litres of pasteurized milk. In the urban system it was not common to sell butter (7% of producers), while about 42% of the peri-urban farmers did so. In the urban system, only one NGO farm produced and sold hard cheese; about 4.5% of peri-urban farmers marketed cottage cheese.

Factors affecting the prices of milk and dairy products included season, fasting and non-fasting days, and access to urban sites; to some extent the quality and sources of dairy products also influenced their price. The price of dairy products was affected by the totally 250 fasting days per year practiced by the followers of the Ethiopian Orthodox Church in which these refrain from eating food of animal origin.

In the urban system, the average daily fresh whole milk sale was significantly ($p < 0.001$) higher (50.6 litre) than in the peri-urban production system (8.8 litre). The price of fresh whole milk per litre was significantly ($p < 0.01$) higher for urban than for peri-urban producers (2.4 versus 2.0 Ethiopian Birr (i.e. 0.28 versus 0.24 USD). Furthermore, the amount of milk sold was significantly ($p < 0.05$) higher during the wet season when cows produced relatively more milk and on non-fasting days as compared to the dry season and fasting days. Related to this, significantly ($p < 0.01$) higher prices were reported for dry and non-fasting periods as compared to wet and fasting periods (2.4 versus 2.1 Birr, i.e. 0.28 versus 0.25 USD per litre).

Neither location nor season significantly affected the average amount of butter sold per farm per week (3.2 and 4.5 kg in the peri-urban and urban area and 3.7 and 4.0 kg in the dry and wet season, respectively). Proximity of the dairy producers to the urban consumers also showed no significant effect on mean butter price, but the mean price for a kg of butter was significantly ($p < 0.001$) higher (24 Birr, i.e. 2.82 USD) in non-fasting periods and during dry season as compared to other seasons of the year (19.5 Birr, i.e. 2.29 USD).

The usual method for buyers to estimate the quality of milk and dairy products was mainly to test a milk sample on smell, appearance and taste. An objective quality testing method reported to be used by 62% of the milk cooperatives was the lactometer (milk density) reading in order to check for possible milk adulteration.

4.3.5. Organization of dairy marketing

The proportion of dairy producers who marketed milk and butter at respective primary outlets and market places is depicted in Table 2. Only informal milk markets were found in the areas studied; these involved direct delivery of raw milk and milk products by producers to consumers in the immediate neighbourhood and sales to itinerant traders, milk cooperatives or individuals in nearby areas. The prices of milk and milk products from the point of production to the next outlets were determined by the producers. No formal marketing system (in which price is usually controlled by the government) was observed. Milk and milk products were transported to market sites on foot, by bicycle and public transport. These means of transport were used by 78.8, 10.6 and 5% of the farmers, respectively. Only very few dairy producers (2.8%) used a private car for transport of dairy products to outlets. Farmers were observed

spending up to 6 hours and 13.6 Birr, i.e. 1.6 USD per round trip for selling milk and milk products. The dairy marketing channels include producers, few cooperatives and other producer groups, first rural assemblers, wholesalers, retailers (hotels, shops, and tea or coffee houses) and consumers. Marketing channels for marketable milk and milk products are described below with traditional butter or ghee having the longest marketing channel; this is the consequence of the participation of more intermediaries between the point of production and the consumer.

Whole milk

Producer → Consumer

Producer → Retailers (hotels, tea and coffee houses) → Consumer

Producer → Cooperatives/producer groups → Consumer

Producer → Cooperatives → Retailer → Consumer

Fermented sour milk/yoghurt

Producer → Consumer

Producer → Retailers (hotels, tea and coffee houses) → Consumer

Producer → Cooperatives/producer groups → Consumer

Traditional butter and/or ghee

Producer → Consumer

Producer → First rural assembler → Consumer

Producer → First rural assembler → Retailers → Consumer

Producer → First rural assembler → Wholesalers → Consumer

Producer → First rural assembler → Wholesalers → Retailers → Consumer

Producer → Cooperatives → Consumer

Producer → Cooperatives → Retailer → Consumer

Producer → Cooperatives/producer groups → Wholesalers → Retailer → Consumer

Cottage cheese

Producer → Consumer

Producer → Cooperatives/producer groups → Consumer

Producer → Cooperatives/producer groups → Retailer → Consumer

Skim milk

Producer → Cooperatives/producer groups → Consumer

The largest primary milk outlets for producers', comprising some 67.3% (urban production system) and 46.1% (peri-urban system) of marketed milk, consists of direct sales of raw milk by producers to consumers, typically through farmer delivery to nearby. For urban producers, the second most important players in the informal markets were retailers (hotels, shops, tea and coffee houses), who handle another 28.6% of marketed milk, and who deliver milk to consumers, while milk cooperatives handled only 4.1% of the marketed milk and sold this to the consumers or other retailers. Contrary to this, the second most important primary outlets for peri-urban producers were milk cooperatives and other producer groups which comprised 44.7% of marketed milk; they mostly processed milk into butter which they sold to consumers or retailers. Only a small proportion of raw milk (9.2%) was sold by peri-urban producers directly to retailers.

Currently the milk cooperatives and other producer groups on average had 48 member farmers, the actual numbers ranging from 25 to 121. The milk cooperatives buy milk mainly from members (95 %) and to some extent from non-members, process it, and sell processed dairy products to traders and local consumers. These groups exclusively focussed on the processing and sale of dairy products; they were neither providing additional services (such as credits, feeds and veterinary services) to the member farmers nor to the buyers. A total of 13 milk cooperatives and other producer groups were found within 17 districts covered in the study areas. At the time of data collection, two of them were not functional due to damage of milk processing equipments. 8 out of the 13 cooperatives and other producer groups were in their initial stage, as they were only certified and started working not until 2006 and thereafter. The average capacity of the milk cooperatives and other producer groups to handle fresh whole milk was 123 and 187 litres per day on fasting days and non-fasting days of the Orthodox Christian Church, respectively. The cooperatives and other producer groups mainly used hand-operated cream separators. Consequently, they produced butter from cream milk. Partially, skim milk was sold to the local consumers; some was fermented to yoghurt, while the rest was further processed into cottage cheese and sold through different outlets. Due to infrastructural constraints (lack of suitable traffic ways, cooling and other devices), losses were reported of 5-50% and of 15-75% of cottage cheese and yoghurt, respectively. All milk cooperatives and other producer groups had only one milk collection site each, which

increases marketing costs for smallholder producers who thereby were forced to travel up to 10 km (round trip) per day to market their milk.

4. 4. Discussion

4.4.1. Milk production and utilization

The higher daily milk production per farm in urban than peri-urban farms is mostly due to the presence of a greater number of crossbred (local zebu type x Holstein Friesian) cows in the first system (11 TLU) than the second systems (1.9 TLU). A similar conclusion was given by Yoseph et al. (2003) and Sintayehu et al. (2008) for the cases of Addis Ababa and Southern Ethiopian highlands. The current study revealed that, more proportion of urban farmers' sale better amount of milk than peri-urban farmers (Fig. 1ab). For urban farmers, the relatively high proportion of milk sale probably was a result of access to a better market which might be related to the increasing urbanization (Azage and Alemu, 1998; Anthony, 2002). Even though, more (9%) urban farmers were observed feeding the calf by bucket than peri-urban farmers which was 3%, generally the practice was not common in the study areas. Comparable results (8.2 and 4.9% for urban and peri-urban areas, respectively) were reported by Anthony (2002) who studied the urban and peri-urban areas of Awassa, southern Ethiopia. This source also confirms the higher rate of home consumption of milk on peri-urban (41.3%) as compared to the urban farms (10%).

As shown in Fig. 1ab and Fig. 2ab, the proportion milk processed and bucket-fed to calves was nearly the same form both the survey and monitoring data analysis. Unlike the survey information, the monitoring data revealed that the proportion of milk used for the household consumption ranked least, while from survey information home consumption had taken the second lead. Such difference might be by chance in which more farmers selling than using for household use selected during sub-sampling and/or the sub-sample size (54 farms) selected might not as representing as main sample size (256 farmers).

4.4.2. Handling of milk processing equipments

One of the major factors affecting the quality of dairy products is related to adequately perform milking procedures and cleanness of the milking utensils (Gonfa et al., 2001). In the current study, almost all farmers cleaned udders before milking. However, the water from bore wells and especially from rivers used for cleaning was probably of doubtful quality, mainly at peri-urban farms. This might jeopardize the effect of cleaning the udder and milking utensils. Procedures of cleaning and disinfection of milking utensils prior to milk collection reported herein, were similar to previous results from Ethiopia (Gonfa et al., 2001; Yousuf Kurtu, 2003; Sintayehu et al., 2008). According to the local understanding, the practice of smoking the vessel by burning wooden chips of specific trees and shrubs has an advantage of imparting special taste and odour to the product, and to disinfect the vessels, thus reducing the numbers of micro-organisms and thereby extending the shelf life of the product. The report of Ashenafi (1996) supported this assumption, as greater numbers and a faster development of aerobic mesophilic micro organisms occurred in milk kept in non-smoked as compared to smoked containers.

4.4.3. Types, processing systems and shelf life of dairy products

Apart from boiling of milk before consumption and putting the container with milk in a cold water bath and to a much less extent in a refrigerator, there were no other (traditional) technologies for preservation of liquid milk. It is obvious therefore, that for technical and economic reasons technologies in fluid milk processing such as steam-pasteurization, sterilization and aseptic packing are not common on Ethiopian smallholder farms (Gonfa et al., 2001; Yousuf Kurtu, 2003; Sintayehu et al., 2008). In the 256 dairy farmers studied, only traditional household utensils were used for collecting or milking, storing and processing. As a result of such technical and economic constraints, the major dairy products found were only fresh milk, naturally fermented milk, traditional butter, traditional ghee, cottage cheese, butter milk and whey. Similar information was published by Gonfa et al. (2001), Yousuf Kurtu (2003) and Sintayehu et al. (2008).

The traditional milk processing is generally time consuming, varieties of products was limited and less milk fat recovery turned into butter per unit of milk processed (ILCA; 1992). If the farmers could not produce greater varieties of products, it is most likely that farmers could not get the full value-added products from milk production. This is probably one reason for the

relatively low proportion of urban dairy producers processing milk into butter. The current observation is in agreement with previous studies conducted in Ethiopia (Sintayehu et al., 2008). Moreover, the proportions of peri-urban producers involved in further processing of buttermilk into cottage cheese was slightly higher than of urban producers. The latter more frequently used buttermilk for bucket-feeding of calves. Another reason for urban producers not practicing this processing might be the lacking availability of fire wood for cooking buttermilk into cottage cheese and whey. Using electric energy for the cooking of buttermilk is economically less favourable than the utilization of buttermilk for household consumption and/or for rearing calves. Similar results were observed by Holloway et al. (2000) who stated that a vast majority of dairy farmers who live far from urban centres in Ethiopia processed milk into different by-products.

To increase the shelf life of milk products, the current practice of further processing of traditional butter and cottage cheese into traditional ghee and Metata Ayib was typical for most smallholder dairy farmers of Ethiopia (Ashenafi, 1990; Gonfa et al., 2001). However, most of the milk processing was done by use of traditional household utensils under unsanitary conditions; to deliver a desirable flavour, plant materials were added to the finished product (traditional ghee and Metata Ayib) might have contributed to the high microbial load. This is in agreement with the report of Ashenafi (1990), Gonfa et al. (2001) and Sintayehu et al. (2008) who worked in similar areas of Ethiopia. Therefore, giving basic handling and health education for producers is likely to result in a better milk quality on the market, including shelf life and aspects of consumers' health.

4.4.4. Marketable dairy products and price factors

Like in most parts of the Ethiopian highlands, mainly raw milk, butter and ghee were marketed by the primary dairy producers. The price and amount of raw milk was significantly higher in urban than in peri-urban areas. Fresh milk could not be kept for a long time before consumed. As a result, dairy producers living distant from urban centres could fetch a relatively lower selling price than farmers in or close to urban centres. This view is supported by Sintayehu et al. (2008) who stated that the distance from market sites (mainly to urban centres) had a major prohibiting effect on farmers from selling whole fresh milk to urban consumers. The current findings are also in line with those of Yousuf Kurtu (2003) who found that dairy producers living far from the urban centres do not deliver milk to the main regional

town (Harar), because of the long distance involved and the high transaction costs. In general, compared with the world, costs of milk production in Ethiopia are low (Staal, 1997), but high transactions costs for households and processors most likely prevent from a potential market entry (Holloway, et al., 2000). In the tropics, the existence of relatively high transaction costs coupled with perishable nature of milk play a central role in limiting dairy production and marketing (Staal et al., 1997). He further stated that under such conditions, milk co-operatives have an advantage as they are able to market larger volumes and sufficiently reduce transaction costs. This underlines the importance of enhancing dairy production and marketing in a coordinated way. Supporting milk cooperatives by provision of technical and infrastructural support may therefore be a specifically efficient for increasing the income of farmers and for providing consumers with more high-quality dairy products.

The amount of milk put on the market was significantly lower during the dry season. This is likely due to a depressed milk yield of cows as a result of feed shortage. The effect of this reduced market supply plus the occurrence of a period with less fasting days resulted in significantly higher market prices for milk and butter. Yousuf Kurtu (2003) and Sintayehu et al. (2008) derived suggestions related to this specific market situation for the Eastern and Southern parts of Ethiopia. In times of low demand for raw milk, farmers were strategically processing of milk into butter and cottage cheese to sale in times of better market. A similar result was drawn by Sintayehu et al. (2008). As the traditional butter and cottage cheese still contain high moisture and do not stay long, the producers frequently processed them further into ghee and Metata Ayib.

4.4.5. Organization of dairy market

As it is also common in most parts of Africa, informal dairy marketing was the sole marketing system in the study areas. Similar findings were reported by Thorpe et al. (2000) for the cases of Kenya and Tanzania and by Yousuf Kurtu (2003) and Nigussie (2006) for the case of the Ethiopian highlands. Milk producers, cooperatives/producer groups, first rural assemblers, wholesaler, retailers and consumers were observed participating in dairy marketing of the study areas. This showed that dairy marketing in the study area involve more intermediaries, each of whom luckily adds some delivery or transformation service to the product. The informal dairy marketing and especially butter marketing found in the study areas involves

more intermediaries; this is likely to affect the producers' price and thereby may eventually influence market supply.

Dairy products such as whole raw fermented and skim milk had short marketing channels which is most likely due to their short shelf life. On the contrary, traditional butter, ghee, cottage cheese and traditional hard cheese showed the longest marketing channels. Hard products such as ghee and traditional hard cheese (Metata Ayib) could stay for about 2.8 years without losing their desired quality for the local users. Traditional ghee is a more convenient product than traditional butter in the tropics, because of its better shelf life even under warm conditions (O'Connor and Trpathi, 1992). In the current study, poor infrastructure and poor logistics for collection, transport and sale of milk and milk products coupled with seasonal fluctuation of market prices due to relatively more supply and refrain of more people from taking milk and milk products during fasting are observed to form a bottle neck in the further development of the dairy sector. Therefore, under difficult market conditions like these, the processing of dairy products into ghee and Metata Ayib and selling those in times of a greater seasonal demand is a promising option.

4.5. Conclusions

Peri-urban producers produce and market less milk per day as compared to urban producers. Patterns of utilization of the produced milk are also different between production systems. Smallholder dairy farmers who have no access to well organized milk storing and processing technologies rely on traditional measures of cleaning their milking and milk processing equipment and the addition of certain plant materials to their products which shall increase the shelf life. However, such techniques may contain health risks and basic handling and health education for producers is likely to help in improving milk (product) quality on the markets.

Direct delivery to the nearby consumers is the most important primary milk outlet for producers of both systems, followed by retailers and milk cooperatives for the urban and the peri-urban system, respectively. Market prices are influenced by season and fasting periods of the Ethiopian Orthodox Church. The coping strategies for producers include focusing on milk processing and selling the processed products at times of higher prices. Relatively high marketing costs further complicate the producers' economic situation. The development of innovative organisational structures such as cooperatives and other forms of producer groups,

and the improvement of infrastructure such as transport, milk collection and milk processing units of a suitable capacity will help to increase the number of marketing options available to smallholder farmers.

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Table 1 Proportion of farmers using different means of preservation for traditional butter and cottage cheese by production system.

Description	Traditional butter		Cottage cheese	
	Urban (N=32)	Peri-urban (N=164)	Urban (N=18)	Peri-urban (N=113)
Spicing*	15.4	64	61	62
Cooling in refrigerator	64	1.8	11	1
Salting	2.6	1.2	-	5.3
Others**	18	33	28	31.7

* Spicing in this context includes further processing of traditional butter and cottage cheese into ghee and traditional hard cheese (Metata Ayib), i.e. after removal of water and spicing.

**Others include consumption and/or selling immediately (within a day) after production and traditional cooling in water bath.

Table 2 Characteristics of relevant points of sale for milk and butter and percentage of producers using these.

Product / point of sale		Customer / site of delivery	Urban production system (N=37 for milk; N=4 for butter)	Peri-urban production system (N=152 for milk; N=83 for butter)
Milk Outlets		Consumers	67.3	46.1
		Retailers*	28.6	9.2
		Cooperatives/producers group	4.1	44.7
Milk Place	Market	Farm gate (homestead)	52.1	32.9
		Open local market	-	2
		Delivery to buyer place	41.7	58.5
		Others	6.2	6.6
Butter Outlets		Consumers	50	72.3
		First rural assemblers	25	24.1
		Retailers	33	3.6
Butter Place	Market	Farm gate (homestead)	25	15
		Open local market	-	70
		Delivery to buyer's place	75	15

*) Retailers in this context includes hotels, shops, and tea or coffee houses

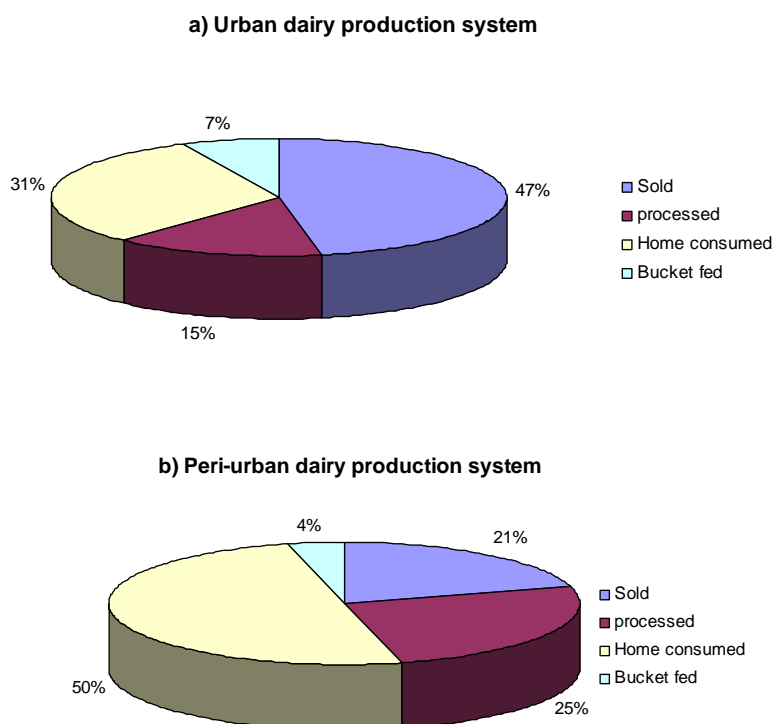
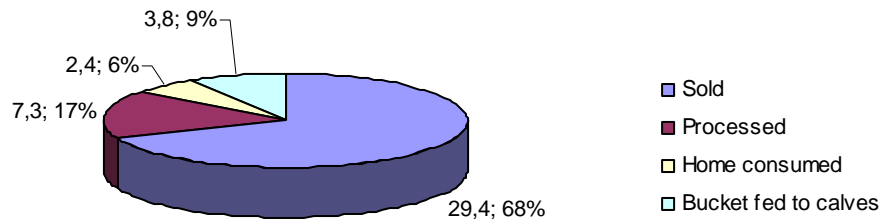


Fig.1ab Proportion (%) of milk utilization in 256 dairy farms in the North western Ethiopian highlands (survey results)

a) Urban dairy production system



b) Peri-urban dairy production system

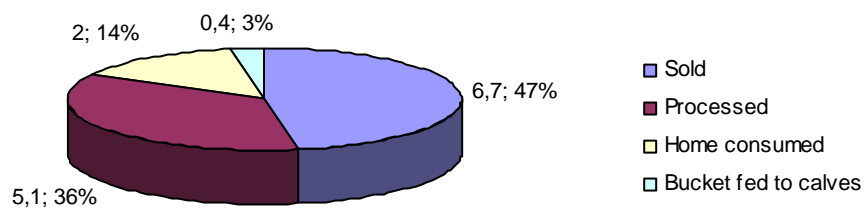


Fig. 2ab Average daily amount of milk produced and utilized (litre/farm) and proportion (%) of milk utilization in 54 dairy farms in the North western Ethiopian highlands (results from monitoring)

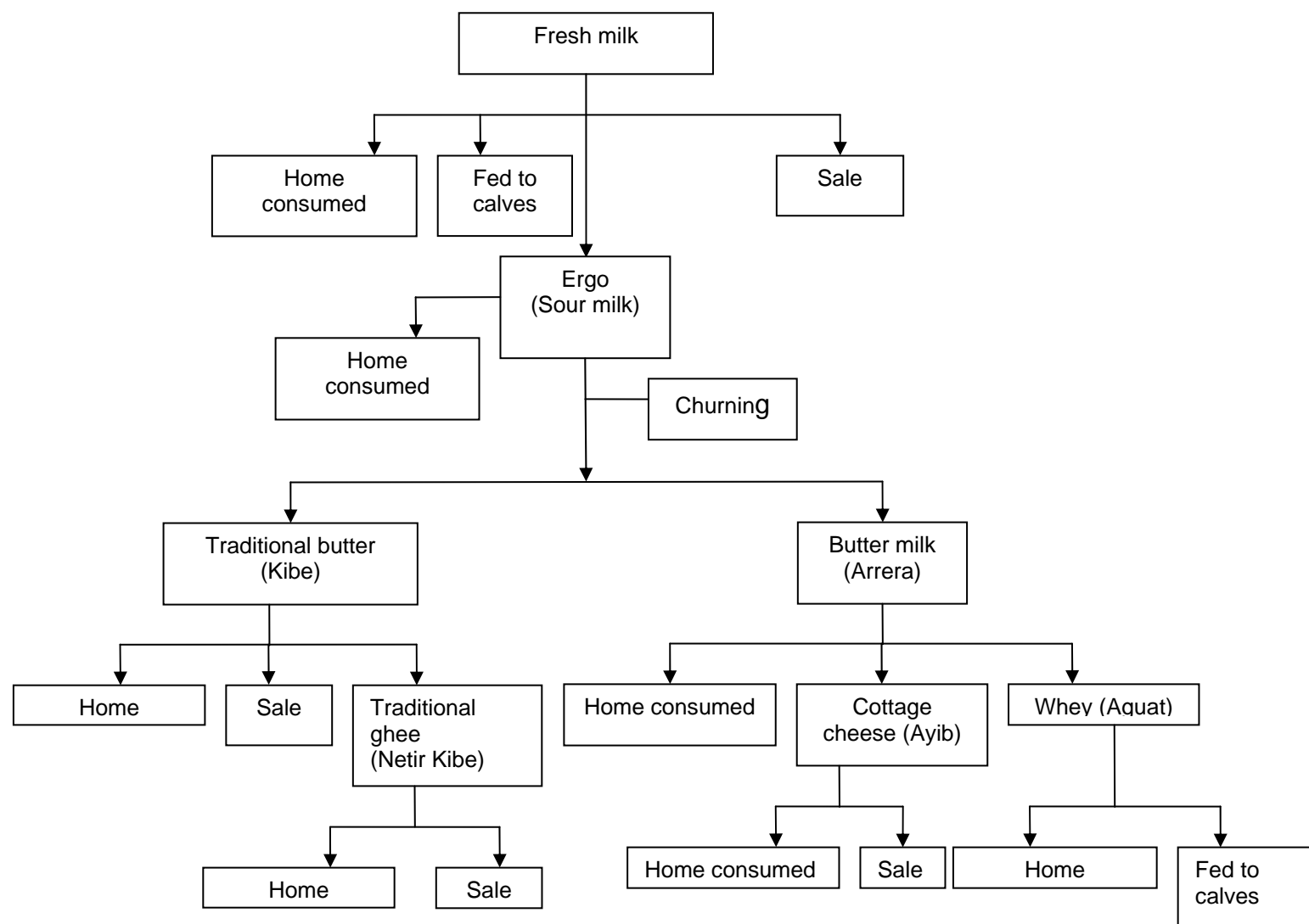


Fig. 3 Flow scheme for milk utilization by smallholder dairy farmers in the North western Ethiopian highlands

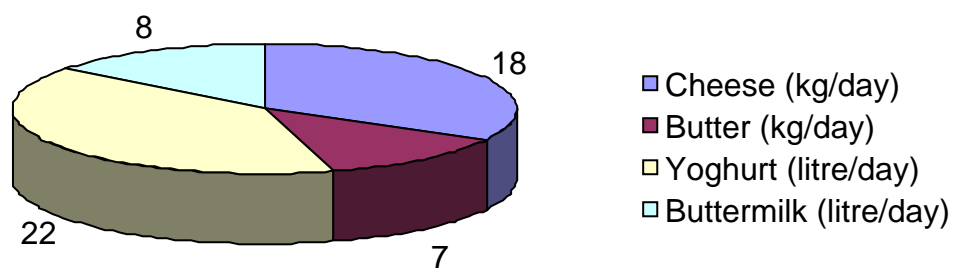


Fig. 4 Amount of milk products sold by milk cooperatives and other producer groups

Chapter 5

General discussion

5. General discussion

Like in other tropical countries, urbanization is rapidly advancing in Ethiopia. For example, the calculated annual human population growth of Bahir Dar and Gondar cities from 1994 to 2006 was 7.1 and 6.7%, respectively, which is well above the national average growth rate of 2.31% estimated for the same period (CSA, 2005). This development tremendously increases the demand for food in general and for protein in particular within urban areas. It has also created a chance for the emergence of urban and peri-urban agriculture. The need of transforming traditional ways of dairy production into modern systems has been evaluated and has started in the early 1950s with the importation of exotic dairy cattle by the United Nations Relief and Rehabilitation Administration (UNRRA). Following this initiation, several governmental and non-governmental organizations have launched dairy development projects in urban and peri-urban areas of Ethiopia (Mohamed *et al.*, 2003), e.g. UNICEF (in 1960), Addis Ababa Dairy Industry (in 1966), Chilalo Agricultural Development Unit project (later called Arsi Rural Development Unit; between 1970 and 1980), Dairy Development Agency (in 1971), Dairy Development Enterprise (in 1979). Among the beneficiaries of the dairy development projects are the subsistence smallholder dairy farms of the milk shed areas studied herein.

Paper one of the current study analyzed the socio-economic characteristics of dairy production systems. The results show that two main dairy production systems exist in the study areas: an urban dairy system within the main cities and a peri-urban system which involves dairying within the secondary towns and at the outskirts of secondary towns and cities. In the highlands of Ethiopia where an integrated crop-livestock farming system dominates, it is a common practice to keep a greater number of cattle along with crop farming (Yousuf Kurtu, 2003). Similarly, in the current study in both the urban and the peri-urban system, a greater number of cattle is found on mixed (crop-livestock) as compared to specialized livestock farms. This is caused, among other factors, by the use of cattle for threshing, crop land preparation and transport. In the mixed farming system of the Ethiopian highlands, a large family size is common and in the first paper it is shown that the average family size of peri-urban farms is higher than of urban farms. The former expend more labour capacity for crop land preparation, manual weeding and harvesting. In this context it may be considered as an asset to have more family members available (ESAP, 2002). This may contribute to improved social security in times of retirement,

The costs of synthetic fertilizers increase through time and farmers are becoming unable to afford those. As a result, in the crop-livestock farming systems of the rural areas of the tropics, manure plays a vital role as fertilizer; this can be another motive for the increased number of cattle in the (peri-urban) crop-livestock farming system in the study area. Urban dairy production provides several benefits both to the producers and to urban and peri-urban dwellers, including job opportunities. The dairy production by its nature is more labour intensive and forms a substantial employment force in the milk shed areas covered in the current study as well as in other parts of the country (Yousuf Kurtu, 2003). It also supports crop farming in the rural areas by providing manure in exchange for the crop residues. Agronomic practices such as manuring, which traditionally helped to counteract the impacts of nutrient depletion by crop production, are disappearing mainly due to severe scarcity of fuel wood and its continuing substitution by animal dung (Shiferaw and Holden, 1998). The results presented in the first paper of the current study indicate that, despite the competitive nature of using manure as fuel and fertilizer, a problem of waste disposal exists in urban areas. Urban farming is done in the form of backyard farming, utilizing vacant space. However, the size of farm land is rather insignificant. The problem of land scarcity is aggravated by the absence of appropriate place to dispose or to utilize animal dung as a fertilizer. Sintayehu et al. (2008) worked in comparable agro-ecological zones and farming systems of Ethiopia and reported that most urban producers pay extra money for labourers to dispose of manure. Among other factors, this might limit a potential herd size growth in urban dairy production.

Higher levels of milk production than those achieved in traditional tropical systems require the introduction of specialized dairy breeds together with increased levels of inputs and a good linkage with markets (Walshe et al., 1991). Therefore, in the second paper of this study, the productivity of dairy cows and input factors such as types of feeds and feeding management measures are discussed. Like in other tropical countries, the intensification of dairy production is based on purchased feeds in the study areas. In the urban dairy production system, feedstuffs used are predominantly purchased concentrates and roughages (mainly hay), while in the peri-urban dairy production system most feed sources were produced on-farm, mainly in form of crop residues and hay. Keeping of upgraded crossbred cows, based on superior Holstein Friesian were also observed as a main feature of an intensified dairy production in the study areas. Both the number and productivity of crossbred cows were higher in urban farms. Nevertheless, the overall performance of dairy cows in the study areas was far from reaching a satisfying level. The results presented in the second paper indicate that in most farms one of the major limiting factors is an

inadequate feed supply. With a growing human population, the competition for land for food and feed production is increasing. As more land is used for crop production, livestock feed becomes scarce and crop residues - particularly cereal straws - remain the major feed resource.

The market factors play a major part in determining the type of dairy production systems found in the tropics (Kruska et al., 1997). Those vary between locations (Walshe et al., 1991). To develop a sustainable dairy development project, evaluation of the market system and careful planning prior to any technological intervention is of paramount importance (Walshe et al., 1991). Therefore, in the third paper of the present study, milk production and utilization, milk handling and processing systems and major marketing situations were investigated across the urban and peri-urban dairy system. Direct delivery to the nearby consumers is the most important milk outlet for producers in both dairy production systems, followed by retailers and milk cooperatives for the urban and peri-urban producers, respectively. Milk cooperatives increase the participation of smallholder in fluid milk markets in Ethiopia (Mohamed et al., 2003). The survival of cooperatives depends on their continued ability to process and sale value-added dairy products and returns that profit to their members (Mohamed et al., 2003). However, in the current study, they are also found to be constrained by the seasonality of milk markets and by a lack of processing raw milk into value-added dairy products.

Peri-urban producers produce and market less milk per day as compared to urban producers. Patterns of utilization of the produced milk are also different between production systems. Smallholder dairy farmers who have no access to well organized milk storing and processing technologies rely on traditional measures of cleaning their milking and milk processing equipment, including the addition of certain plant materials to their products which shall increase the shelf life. However, such techniques may contain health risks and basic handling and health education for producers is likely to help in improving milk (product) quality on the markets.

According to FAO (2001) markets for dairy products typically differ in several key aspects, such as the types of products handled, the number of intermediaries involved, and the role each of them plays. These two aspects are frequently linked: processed products are usually of a higher value, but often involve additional intermediaries, each of whom adds some delivery or transformation service to the product. Just an increasing distance between source and selling point, or the density and scale of the production system, even without product transformation, can result in an increasing number of intermediaries, due to the need for assembling, bulking,

transporting and distributing. As discussed in paper three, the informal dairy marketing and especially butter marketing found in the study areas involves more intermediaries; this is likely to affect the producers' price and thereby may eventually influence market supply.

In general, the development of innovative organizational structures such as cooperatives and other forms of producer groups, and the improvement of infrastructure such as transport, milk collection and milk processing units of a suitable capacity will help to increase the number of marketing options available to smallholder farmers.

In conclusion, the great potential of urban and peri-urban dairy production for contribution to food security of the population, to family income and for providing a job opportunity will be better realized if current deficiencies in the access to services such as the transfer of technical knowledge, artificial insemination, veterinary and credit services are resolved. Limitations in the access both to agricultural land (especially for urban producers) and market sites (for peri-urban farmers) are also likely to hamper the development of this sector and need to be addressed by specific policy schemes. Another element of the production chain which deserves special attention is the currently poor manure collection, transport and disposal in urban areas and the potential health hazards and environmental pollution originating from this.

Recommendations

Recommendations drawn from the current study are addressing three levels: extension, policy and research.

Extension level

- As observed in the current study, the smallholder dairy farmers will likely dominate the sector. Extension workers should therefore also promote integration of crossbred cattle into the smallholder sector through improving their access to artificial insemination, veterinary and credit services.
- Shortages of feed both in quantity and quality likely remain as major constraints in the study areas. These constraints should be addressed by supplying improved forage seeds and promoting the production and feeding systems.
- Transfer of technological knowledge into feeding, housing, breeding and milking management is also important to boost up the dairy sector.

- Poor manure collection, transport and disposal in urban areas and the potential health hazards and environmental pollution could remain as another major constraint. To address this, coordinated effort in awareness creation and promotion is necessary.
- Consumption of dairy products should also be stimulated in the study areas, because of its contribution to a balanced nutrition; furthermore, market fluctuations and temporarily low demand for dairy produce can potentially discourage production in the long run. This need to be addressed by developing appropriate promotional concepts such as world school milk day and milk school programme.
- Establishment and strengthening of milk cooperatives through providing continuous training in processing and handling of value-added milk products could increase the market entry options.

Policy level

- Very limited access to credit services was observed in the study areas which could limit the potential expansion of dairy farms, including processing and marketing by smallholder farmers. Therefore, politics should take the lead in promoting credit services.
- A limitation in access to farm land mainly for urban producers is likely to hamper the development of the dairy sector. Moreover, urban agriculture is done on land in transitional use and where rights of usufruct are at issue which most likely leads to low investment and consequently to low productivity. Hence, these constraints need to be addressed by specific policy schemes.
- The perishable nature of raw milk and high transaction costs could remain major constraints for the development of the dairy sector by limiting the participation of dairy farmers, mainly those from the peri-urban areas. Enhancing dairy production, processing and marketing in a coordinated way is paramountly important. Hence, politics should take the lead to strengthen cooperatives by providing technical and structural support.
- In order to minimize the animal and human health hazards and environmental pollution, development and implementing of appropriate mechanism in collecting, transporting and disposing manure from urban farms is urgent.

Research level

- In the current study, no economical analysis of the utilization of more concentrates and improved forages was performed. Therefore, further studies shall focus on a cost-benefit analysis of the production and utilization of greater quantities of concentrates and/or

improved forages and the identification of alternative feed resources in order to improve milk production and increase income from such an activity.

- Plant materials were added to the finished product which might have an effect on the microbial load and other quality traits. Therefore, understanding the effect of adding plants to milk products and developing appropriate technologies is of great importance. In addition to that, developing appropriate technologies for production of more value-added dairy products such as table butter, hard cheese, fruit yoghurt and the like could help producers to cope with the market fluctuation problem.
- Informal dairy marketing involves more intermediaries; this is likely to affect the producers' price and thereby may eventually influence market supply. Therefore, evaluation and documentation of the advantages and disadvantages of different marketing options and developing of alternative milk marketing systems in terms of costs and marketing margins, product quality, range and stability of services offered and stability of producers' and consumers' prices call for detailed studies.
- Projection of the urban and peri-urban dairy systems and analysing risks and documenting risk averting mechanisms could help to take appropriate measures timely. Therefore, projection of the short-term and long-term future aspects of dairy development in the Ethiopian highlands is of paramount importance.

Chapter 6

Summary

6. Summary

The current study was carried out between July 2006 and March 2007 in the milk shed areas of the North western Ethiopian highlands with the objectives to evaluate the socio-economic characteristics of dairy farms, the proproductive and reproductive performance of dairy cows, milk handling, processing and marketing. Data were collected at total of 256 and 54 dairy farms, using a survey and monitoring approach, respectively. In addition to this, the statuses of milk cooperatives/producer groups were surveyed to evaluate their potential as options for smallholder dairy farmers to enter milk markets.

Based on breed, land size, feed and market accessibility, two major dairy production systems were identified: an urban and a peri-urban dairy production system. In general, urban agriculture includes farming activities taking place on vacant and under-utilized land areas within the inner cities and major towns, whereas peri-urban agriculture means farming in the urban periphery. Urban dairy farmers specialize on milk production while peri-urban farmers integrate milk production with other farming activities. Among other factors, the specialization of the urban dairy producers also includes a more frequent utilization of crossbred cows (local x Holstein Friesian) as compared to peri-urban producers. Urban farmers support the family income from milk sale with income from non-agricultural activities, while agricultural activities other than milk production form important additional sources of income in peri-urban farms. Urban producers farm less land and sell a greater proportion of the milk produced than peri-urban farmers, who processed more milk. Urban farmers mainly depend on purchased feeds, while in the peri-urban dairy system most feedstuffs are produced on-farm (mainly crop residues and hay). Generally, the quantity and quality of feeds available were found to be insufficient to support full expression of the genetic potential of dairy cows.

Although crossbred cows performed better than local cows when evaluated based on the economically most important traits such as daily and lactation milk yield, age at first calving and calving interval, the overall productive and reproductive performance of dairy cows did not reach a satisfactory level. If the performance of dairy cows and family income from milk production is to be increased, the management of dairy cows will need to be improved substantially. This includes among others an efficient heat detection and timely insemination, better health management, genetic improvement of local breeds by pure breeding and/or crossbreeding and supplementation of poor quality feed resources.

In addition to the differences in the amount of milk produced and sold per day, the patterns of utilization of produced milk were also different between production systems: smallholder dairy farmers who had no access to well organized milk storing and processing technologies rely on traditional measures of cleaning their milking and milk processing equipment and on the addition of certain plant materials to processed dairy products which shall increase their shelf life. However, such techniques may contain health risks and basic handling and health education for producers is likely to help improving milk (product) quality on the markets.

Dairy marketing is completely informal in the study areas. It nevertheless involves a certain number of intermediaries, who add some delivery or transformation service to the product and thereby increase the price of the milk (products) for consumers and/or force producers to reduce their price at the point of production. This in turn might have a negative impact on dairy development by limiting the demand for milk products and/or affecting the motivation of producers to supply sufficient amounts of milk (products). However, the direct delivery to nearby consumers is currently the most important primary milk outlet for producers in both systems, followed by retailers and milk cooperatives for the urban and the peri-urban system, respectively. Market prices are influenced by season and fasting periods of the Ethiopian Orthodox Church. The coping strategies for producers include focussing on milk processing and selling the processed products at times of higher prices. Relatively high marketing costs further complicate the producers' economic situation.

The major constraints for dairy development in the area include little availability and high costs of feeds in connection with a shortage of farm land, poor access to waste disposal, poor market infrastructure and marketing systems, a lack of improved dairy cows, poor extension, training, artificial insemination and animal health services, a shortage of credit services and a general gap in the knowledge about improved dairy production, processing and marketing. These shortcomings must be solved if the production systems described herein shall be developed towards a sustainable and profitable dairy supply in the North western Ethiopian highlands.

Zusammenfassung

Zwischen Juli 2006 und März 2007 wurden im nordwestlichen äthiopischen Hochland Daten gesammelt, um die sozio-ökonomische Situation, die tierische Leistung, die Milchgewinnung, –verarbeitung und –vermarktung zu charakterisieren. 256 bzw. 54 milchviehhaltende Betriebe wurden befragt bzw. über einen längeren Zeitraum beobachtet. Zusätzlich wurde die Situation von Erzeuger-Genossenschaften untersucht, um deren Potenzial als kleinbäuerliche Vermarktungsorganisationen festzustellen. Basierend auf der verwendeten Rasse, der verfügbaren Fläche, dem Zugang zu Futtermitteln und Märkten wurden zwei unterschiedliche Produktionssysteme identifiziert: die urbane und die peri-urbane Milcherzeugung. Urbane Milcherzeugung ist innerhalb größerer Städte, die peri-urbane vor allem an der Peripherie der Städte anzutreffen. Urbane Milchproduzenten spezialisieren sich zumeist auf die Milcherezeugung, wohingegen peri-urbane Milcherzeugung in andere landwirtschaftliche Betriebszweige integriert ist. Die Spezialisierung im städtischen Bereich beinhaltet auch den häufigeren Einsatz von Kreuzungskühen (Lokalrasse x Holstein Friesian). Neben dem Verkauf von Milch(produkten) tragen außerlandwirtschaftliche Tätigkeiten zum Familieneinkommen im urbanen Bereich bei, während peri-urbane Betriebe neben der Milcherzeugung noch andere landwirtschaftliche Aktivitäten durchführen. Betriebe in den Städten verfügen über deutlich weniger Land zur Produktion; sie verkaufen einen größeren Anteil der produzierten Milch als die peri-urbanen Bauern, für die die Weiterverarbeitung von größerer Bedeutung ist. Die Futterbasis besteht im städtischen Bereich aus Zukaufsfutter, während die peri-urbane Milcherzeugung auf betriebseigenen Futtermitteln (v.a. Ernterückstände und Heu) beruht. Im allgemeinen reichen Qualität und Quantität der verwendeten Futtermittel nicht aus, um das genetische Potenzial der Kühe auszunützen. Obwohl Kreuzungskühe höhere Leistungen als lokale Kühe aufweisen, war das Leistungsniveau insgesamt relativ niedrig. Wenn dieses und damit auch das bäuerliche Familieneinkommen angehoben werden sollen, müssen Verbesserungen in Haltung und Management erfolgen. Insbesondere die Bereiche Brunstkontrolle, künstliche Besamung, Tiergesundheit und züchterische Maßnahmen sowie das Fütterungsmanagement weisen ein erhebliches Optimierungspotenzial auf.

Nicht nur die Produktionsleistung, sondern auch die Art der Milchverwertung war zwischen den beiden Produktionssystemen verschieden: Kleinbäuerliche Milcherzeuger ohne Zugang zu modernen Milchlagerungs- und –verarbeitungstechnologien greifen auf traditionelle Methoden der Reinigung, aber auch der Verlängerung der Haltbarkeit von Milch und Milchprodukten beispielsweise durch Zusatz bestimmter Pflanzen zurück. Diese Methoden können allerdings

auch ein gewisses Risiko für die Produktqualität darstellen und sollten durch einen entsprechenden Wissenstransfer bezüglich der grundsätzlichen Handhabung sowie Gesundheitsfragen ergänzt oder ersetzt werden.

Die Milchvermarktung erfolgt in den untersuchten Regionen gänzlich über informelle Kanäle. Trotzdem sind dabei auch eine Reihe von Zwischenhändlern involviert, die Verteilungs- und Transportfunktionen übernehmen, was aber zu einer Erhöhung der Verbraucherpreise oder/und zu einem Druck auf die Produzentenpreise führt. Die Marktpreise unterliegen generell einem jahreszeitlichen Einfluss und sind auch von religiösen Fastenzeiten beeinflusst. In Zeiten niedriger Preise wird mehr Milch zu lagerfähigen Produkten verarbeitet. Der Verkauf an Letztverbraucher stellt in beiden Systemen den wichtigsten Verkaufspfad dar, gefolgt von Wiederverkäufern (urbanes System) bzw. Erzeugergenossenschaften (peri-urbanes System). Hohe Vermarktungskosten können für die Erzeuger ein weiteres Problem darstellen.

Der Entwicklung der Milcherzeugung stehen somit vor allem Faktoren wie geringe Futtermittelverfügbarkeit, hohe Futterkosten in Verbindung mit dem Mangel an landwirtschaftlichen Flächen, Entsorgungsschwierigkeiten betreffend Wirtschaftsdünger und Abfällen, eine unterentwickelte Marktinfrastuktur, der Mangel an genetisch gut veranlagten Tieren, an Wissen über Produktion, Verarbeitung und Vermarktung sowie fehlende Dienstleistungen entgegen. Diese Defizite müssen behoben werden, um die beschriebenen Produktionssysteme in Hinblick auf ihren Beitrag zur Ernährungssicherung im nordwestlichen äthiopischen Hochland weiter zu entwickeln.

Combined references for chapter 1 and 5

7. Combined references for chapter 1 and 5

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Appendix

Pasture evaluation



Site selection



Natural pasture sampling site



Cutting pasture samples



Weighing samples

Focussed group discussion



Bahir Dar, Ethiopia

Functions of livestock



For transportation



For food



For thrashing



Manure of them as a fuel

Feeds and feeding



Open grazing pasture



Crop residues



Brewery by-product



Hay



Improved forages

Housing systems of dairy cows



Poor drainage



Space problem



Non-paved room



Better housing system in the city

Types of dairy products



Raw milk



Spiced butter



Cottage cheese



Yoghurt for sale

Milk utensils



Gourd-traditional churner



Gourd for milking and marketing



Clay pot for churning and storage



Plastics for milking and storage

Role of women in dairy farming



Cleaning is mainly done by women



Processing is mainly done by females



Feeding and watering in the barn



Providing information during field visit