“There is no finer investment for any community than putting milk into babies”

Winston Churchill (1874-1965)

DAIRY CONSTRAINT ANALYSIS IN ERITREA, WITH SPECIAL EMPHASIS ON ASMARA AND SURROUNDING DAIRY FARMS

by

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THESIS

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Declaration

I Mr Alemseged Moges Weldeselasie hereby declare that the research reported in this thesis is the result of my own investigations, except where acknowledged, and has not, in its entirety or part been previously submitted to any University or Institution for degree purposes.

Signed ______________________

I Dr Nsahlai, I. V., Chairperson of the Supervisory Committee, approve release of this thesis for examination.

Signed ______________________

ACRONYMS

A.I.	Artificial Insemination
ADA	Average daily gain/day of Age
ADG	Average Daily Gain
ADP	Asmara Dairy Plant
AFC	Age at First Calving
ARD	Animal Resources Department
ASMDFCA	Asmara and Surrounding Modern Dairy Farmers Cooperative Association
AU	Animal Unit
BOMA	British Overseas Military Administration
BP	Breeding Period
CI	Calving Interval
CSV	Comma Separated Value
DANIDA	Danish International Development Authority
DDE	Dairy Development Enterprise
ECCE	Entre Cooperativa Dielle Consumo Eritreo (former Italian name for Asmara dairy plant)
EMPP	Ethiopian Milk Pasteurising Plant
EPLF	Eritrean Peoples Liberation Front
FMD	Foot and Mouth Disease
GDP	Gross Domestic Product
GLM	General Linear Model
HRD	Human Resources Development
ICP	Intercalving Period
LSM	Least Square Mean
MoA	Ministry of Agriculture
Nfa	Nakfa (Local Currency of Eritrea)
NIRD	National Institute of Research in Dairying
NLDP	National Livestock Development Policy
^{0}C	Degree Celsius

ODA	Overseas Development Administration
S.D.	Standard Deviation
SAS	Statistical Analysis System
SPC	Services Per Conception
SSA	Sub-Saharan Africa
RMSE	Root Mean Square of Error
UKODP	United Kingdom Overseas Development Project
VWP	Voluntary Waiting Period

SUMMARY

The overall objective of the study reported in this thesis was to assess the existing situation of the dairy sub-sector in Eritrea with special emphasis on the Asmara and surrounding dairy farms. The specific objective was analyse historical data and carry out a survey to identify the constraints of the dairy sub-sector in Eritrea.

Historically, commercial dairy farming in Eritrea was started by Italian settlers during the 19th century when Eritrea was under Italian colonization. The growing demand for milk and milk products, especially in the urban centres stimulated the development of dairy farms by Italian settlers who owned large areas of fertile land mainly in the highlands, in which they established modern dairy farms using high merit dairy breeds such as the Holstein-Friesian. The introduction of artificial insemination (AI) in 1938 by the Italians for research purpose at the Veterinary Institute also contributed to dairy development. Based on the efficiency of A.I. services over time, four phases of development were identified. During 1972-1976 good achievement per inseminator and high effective inseminations were recorded. In 1978 -1980 the achievements declined but with increased number of calves and high effective inseminations as compared to phase one. From 1982-1989 the activity increased with effective inseminations ranging from 48-75.3%. During 1992-2000 effective inseminations ranged from as high as 58.8% to as low as 31.3%. Effective inseminations increased with the increased number of A.I. technicians. The highest achievements were recorded during the years 1993, 1998 and 1999.

A survey was conducted on urban and peri-urban dairy farmers located in and around Asmara. Thirty dairy farmers were randomly selected and interviewed. Data on herd composition and breed, feed type and source, type of mating, dairy housing, health, farmers' status, milk production and marketing, problems and constraints faced by dairy farmers were collected. Interviewed farmers were characterised based on location, herd size, health service, and farmers' status. Dairy farmers varied in their access to forage. High proportions of peri-urban farmers have access to cultivated forage while high proportions of urban farmers have access to purchased forage. Usage of cultivated and purchased forage were related to location ($p<0.05$). Natural, AI and combined systems of mating were used by 86.7%, 3.3% and 10% of

farmers, respectively. Both urban and peri-urban farmers used the in-door system of housing. Foot and mouth disease (FMD), lumpy skin disease, nutritional disorders, mastitis, abortion, tuberculosis and digital problems were the most prevalent diseases. Dairying was considered by a majority (73%) of farmers as a primary means of income but by 27% as a part time means of earning an additional income. A large amount (67%) of milk produced was marketed through the formal channel while the rest (23%) was sold directly to consumers.

Secondary data were collected from different institutions and libraries such as MoA, ASMDFCA and Asmara Pavoni social centre, through personal contacts with various individuals. A data set of 563 dairy farmers that included information on farm identification number, location, breed, herd structure (cows, calves, heifers, bulls), milk yield/farm/day and milk yield /cow/day was subjected to cluster analysis. The main objective of clustering was to classify farmers according to their characteristic features. Three clusters, namely clusters 1, 2 and 3, were identified and had, respectively 47.04%, 45.06% and 7.91% urban (n=253) and 37.13%, 61.56% and 1.3% peri-urban (n=307) farmers. Clusters 1, 2, and 3, had 10±0.6, 5±0.5, 23±1.82 cows, and produced 49.7±3.45kg, 24.3±3.02kg and 117±10.73 kg of milk/farm/day, respectively.

A group survey was conducted to identify the major constraints impeding dairy production. Pairwise ranking of the identified problems was done using a matrix. The constraints subjected to pairwise ranking were: feed shortage, lack of co-ordination, lack of skilled manpower, disease and shortage of veterinary drugs, lack of extension package, shortage of land, lack of milk cooling and transport facilities, lack of know-how and inconsistent AI service. Shortage of land, feed shortage and lack of co-ordination were identified as the major constraints facing dairy farmers.

Dairy herd constraint analysis was also done on Elabered estate dairy. It is the only dairy farm that keeps dairy records. Data on lactation number, breed, last calving date, A.I. date and due date, body weight and height, milk yield per cow, condition score, number of AI's and pregnancy status of cows, were analysed using "Gwion dairy analysis programme by dairy man". Mean milk yield, condition score and average live body weight of the herd were 11.6±2

kg/day, 2±0.56 and 497.63±89 kg, respectively. Days in milk of first calvers and older cows fell between the ranges of 41-327 and 201-245 days, respectively. First and second calvers were below target average mature body weights. Mean age by stage of lactation of cows was 3.3±1.8 and mean age at first calving of the herd was between the range of 39-43 months. Mean calving interval (CI), calving interval spread index, voluntary waiting period, average services per pregnant cows (SPC) and maximum services per conception were 435 ±88days, 55, 52days, 1.8±1.1 and 7, respectively. Poor heifer growth and poor fertility status were major constraints identified. The suspected causes were poor data management, poor heat detection and poor nutrition.

Generally, the dairy sub-sector in Eritrea comprises urban and peri-urban dairy farms of different sizes operating in and around urban centres. The sustainability of the systems will be determined by their location towards the centre. With the expansion of towns and residential areas some dairies may discontinue. Social, environmental and economical aspects should be given due consideration for sustainable dairy production systems. Therefore, identifying the target group should help to intervene and solve constraints.

Dedication

This thesis is dedicated to Moges family

Specially to my beloved Mother Mrs Aregash Merach, my late brothers Tsehaie Moges, Tekle Moges and Adhanom Moges who gave their sacred lives for the freedom of their land.

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Last but not least I would like to say I might not have been able to pursue this study without the full cooperation and tolerance of my family. I express my admiration and gratefulness to my wife Meaza and my children Bethel, Abigail and Tsehaie for their patience during the time I was away from them. I thank God Almighty for seeing me from beginning to end of the study.

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CHAPTER ONE

GENERAL INTRODUCTION AND REVIEW OF LITERATURE

1.1 COUNTRY BACKGROUND

Eritrea is located in the Horn of Africa, extending over 1,000 kilometres from Ras Kassar in the north to Ras-Dumeira in the south in the strait of Bab-el-Mendeb. Ethiopia and Sudan lie to the west of the country and Djibouti to the east. Eritrea covers (including the Dahlak archipelago) an area of 124,324 square kilometres.

The country comprises a high plateau and a coastal plain. The altitude ranges from the highest mountain, Amba Soira (3,010 metres a.s.l.), to the Danakil depression (100 meters below sea level). The coastal plain consists of semi-arid desert. Off the port of Massawa is the Dahlak archipelago, more than 300 islands. Eritrea is strategically located, between 12^0 42'- 18^0 2' N and 36^0 30'- 44^0 20' E (Figure 1.1).

Administratively, Eritrea is divided into six Zobas with 54 sub Zobas and about 2685 villages. The population of the country is estimated at about 3.5 million with rural/urban ratio of 80: 20%. One seventh of the whole population lives in the capital city, Asmara and roughly, about 50% of the total population is below 18 years of age (FAO, 1994). Eritrea has nine ethno linguistic groups whose boundaries overlap to a certain extent with geographical boundaries and modes of life. The *Tigre, Saho, Afar, Hidareb* and arabic speaking *Rashaida* are mainly transhumanic pastoralists and agro-pastoralists who are Muslims and mainly inhabit the Anseba, Northern Red Sea, Southern Red Sea and Gash Barka Zobas. The *Bilen, Kunama, Nara* and *Tigrigna* ethnic groups are settled agriculturists and with the exception of Muslim Naras, are mainly Christians. The *Bilen* and *Tigrigna*, live in the central highlands, mainly in Anseba, Debub and Maekel Zobas while the *Kunama* inhabit the Gash Barka Zoba in the western lowland.

1.1.1 Agricultural Profile of Eritrea

Agriculture is the mainstay of the Eritrean economy accounting for about 50% of the GDP and involving 70 to 80% of the small subsistence farmers.

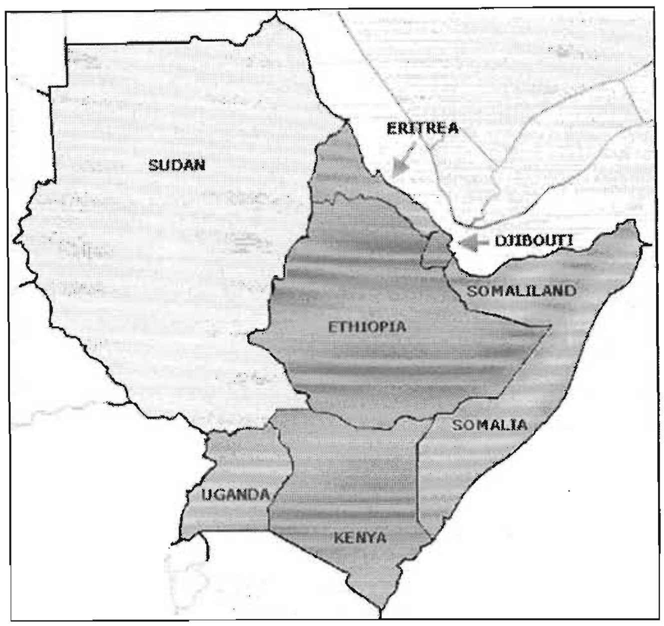

Figure 1.1 Location Map of Eritrea

1.1.2 Climate

The climate of Eritrea is influenced by the topography. Conditions range from hot and arid in the coastal plains to cool in the highlands. Mean annual temperature in the lowlands varies between 26.5°C and 29°C. The hottest temperatures occur in the Southern Red sea zone in the Denakil depression, where peaks of over 50°C have been recorded, while the lowest temperatures occur in the highlands, where freezing temperatures occur at night in the months of December, January and February. The problem of inadequate total rainfall over most of the country is compounded by the high variability of both total rainfall and its distribution. Like the rest of Sahelian Africa, Eritrea receives its rainfall from the Southwest monsoon from April/May to September/October except for the coastal area that receives monsoon rains from the Indian Ocean. The rain is bimodal starting with short rains in April/May, followed by a dry period before the main rains come from July until October.

Table 1.1 Agro-Ecological zones in Eritrea

	Characteristic Feature		
Ecological Zone	**Altitude (m.a.s.l.)**	**Rain fall (mm)**	**Features**
Central Highland	>1500	>500	
Western Escarpment	750-1500	Up to 500	Transitional zone between the central highland and South western Lowland
South Western Lowland	600-750	500-700	
Green Belt	750 to >2000	700-1000	Cultivation of permanent trees and crops is possible without irrigation
Coastal Plain	< 600	< 200	Hot desert climate, pastoral area
North -Western Lowland	400-1500	Up to 300	Extensive transhumance is practiced

1.1.3 Farming systems in Eritrea

The agro-ecological zones in Eritrea are given in Table 1.1. In the Coastal Plain and North-Western Lowland zones crop production is not possible without irrigation. Although pasture resources are poor to moderate, the economy of these areas is largely based on extensive transhumanic pastoral systems. The ecological and cultural diversities determine the type of agriculture practised in the different ecological zones of the country. Three different farming systems exist in Eritrea (Table 1.2).

Table 1. 2 Farming systems in Eritrea

System	Main activity	Zone & population
Sedentary mixed	Food crops, cattle, sheep, goat, equines and poultry rearing	About 60% population of Central highlands
Agro-pastoral	Semi-nomadic, cattle, sheep, goats, equines and camel rearing, one or two staple crops cultivated	Coastal plain inhabited by about 34% of the population
Pastoral	Nomadic, only livestock rearing	4-6% of the farming population

Livestock rearing is an integral part of the Eritrean agriculture without which no single agricultural activity is performed. Cattle are by far the most important species. In the sedentary farming system, in the highlands, cattle are reared for dual purpose, mainly for draught use, than for milk and meat. In the other two farming systems mainly in the lowlands, cattle are the main source of food in terms of milk and meat. Small ruminants and poultry are mainly kept as a source of immediate cash. The livestock resources in Eritrea have been seriously affected by 30 years of war, consecutive droughts and erroneous policies. Due to these factors, the Ministry of Agriculture (MoA) estimated that the livestock population in Eritrea fell by 50 to 70% in the last two decades (Table 1.3). Of the total national herd, some 60% are located in the lowlands, and the remainder in the highlands.

Livestock owners in the lowlands form two groups: the agro-pastoralists, and the pastoralists. In the wet season, pastoralists graze the poor areas to avoid flies and mosquitoes, thereby saving the riverine areas for the dry season. Pure pastoralists are mainly concentrated in the extreme north, in the Sahel and northern Barka province, and in the southern panhandle of Dankalia. Overall, the traditional system of livestock management and grazing by pastoralists is rational and represents an efficient use of transient resources.

1.1.4 Breeds of Cattle

There are at least four local cattle breeds in Eritrea namely the *Barka* (*Bigait*), *Arabo* (*Bahria*), *Arado* and *Afar*. All are humped and belong to the genus *Bos indicus*. The latter two breeds are mainly used for draught and meat, while the Begait and Arab breeds are the predecessors of the present dairy population in the country.

The ***Arado*** breed has a small compact body size mainly used for draught and meat. It is believed that because of its small body size it tolerates feed shortage and can withstand the drought. It is low in milk production and is estimated to give maximum of 4 litres/day at peak production.

The ***Barka*** **(*Begait*)**, a black and white spotted less docile breed, is mainly reared in the north and western lowland parts of Eritrea. Although no detailed study has yet been done, it is believed that there are about five strains of this breed. One of these is the Rafian, which resembles the Holstein-Friesian. Under optimal management condition cows of this strain give above 15 litres of milk per day. In general all Begait strains of cows have a long and narrow head with short horns, long legs and sloppy rump. Most of the cows have a well developed but pendulous udder. They are good for dairy and meat purposes (Mason, 1996). Begait breeds give, on average, 10 litres of milk per day and can be maintained on poor quality forage for a long period. Forming the nucleus of many dairy herds, the Begait breed is suitable for crossing with Holstein-Friesian and other exotic bulls (Tesfaye, 1992). Teclu (1995), referring to former dairy farmers, reported that when crossed with Holstein Friesian, their F1 gave higher milk yield, growth rate and reproductive efficiency than their Begait mothers and were superior with respect to disease resistance, mortality and feed requirement relative to the Friesian parent as a result of heterosis.

The ***Arabo*** **(*Bahria*)** breed is mainly found around the Red Sea coast. Although not considered as an economically important breed it is believed that under good management condition cows of this breed can give 8–10 litres of milk per day. The breed requires less feed and is favourable to cross with exotic dairy breeds. The ***Afar*** breed of cattle has not been characterised.

Table 1. 3 Estimates of Livestock Population ('000 head)

Year	Cattle	Goats & Sheep	Camels	Equine	Poultry
1928	749	1897	79	59	-
1938	591	1491	68	51	-
1946	1200	2200	105	83	-
1965	1300	3200	180	109	-
1973	2500	5000	-	-	-
1987	970	3001	-	90	456
1992	1300	4950	185	76	2500
1997	1900	6700	300	520	2600

Source: MOA

1.2 HISTORICAL BACKGROUND OF THE DAIRY SUB-SECTOR IN ERITREA

Commercial dairy farming was started in Eritrea by the Italian settlers during the 19^{th} century when Eritrea was under Italian colonization. The growing demand for milk and milk products especially in the urban centres stimulated the development of dairy farms by Italian settlers who were given large areas of fertile land mainly in the highlands to establish modern dairy farms using high merit dairy breeds such as the Holstein-Friesian. These farms were intensively managed and were the main suppliers of milk to the urban population, particularly to the Italian community residing in major towns. According to Zeggu (1997), the commercial dairy sub-sector reached its peak in the 1970's when the daily milk production around Asmara was over 30,000 litres and some of the farms such as Elabered and Marassani had daily milk production of about 10,000 and 3,000 litres, respectively.

The establishment of an American Military base in Eritrea increased the demand for milk and milk products substantially (Teclu, 1995). The increased milk demand encouraged low resource producers to enter the enterprise and produce milk for commercial purposes. Many Eritreans employed in the Italian farms developed skills in intensive dairy farm management. Some of these started to establish small-scale commercial farms using local dairy cows. Because of efficient breeding and reproduction of the imported Holstein-Friesian breeds and the use of artificial insemination (AI) services on Italian farms, the number of exotic dairy animals started to grow gradually. During that period the average achieved conception rates were about 80%. Partly because of the success of the service, most dairy farmers replaced their bulls with AI within a couple of years (Zeggu, 1997).

The milk treatment plant at Asmara was established in 1942 just after the Italians were defeated in Eritrea and succeeded by the British Overseas Military Administration (BOMA). The private enterprise was known as "*Entre Cooperativa dielle Consumo Eritreo* "(ECCE). It was established to supply clean milk to the then large Italian community residing mainly in urban centres such as Asmara, Massawa, Dekemhare and Keren. The commercial dairy farming sector in peri-urban areas was not adequately developed resulting in inadequate milk supply to the dairy plant, which as a consequence organized milk supply from traditional producers. Milk collection centres for smallholder or traditional producers were established along the main roads in the highlands and parts of the lowlands. At collection, points milk was subjected to preliminary tests for acidity and adulteration with water. The milk in each reception point was bulked in large churns and carried in vehicles principally to Asmara (the largest consumer centre), and to other urban centres, where it was pasteurised and distributed or processed into butter and cheese. This system of distribution was later discontinued because milk keeping was poor due to poor hygiene at production point and poor transportation system between collection and processing centres.

From the early 1940's up to the 1960's there was a milk collection scheme in the western lowlands that served the pastoral areas, and serviced the processing plant in Keren town (the then centre of the Senhit province). The milk collection centres were located along the railway line, thus transportation was by train. There are still remnants of the collection infrastructures today (Personal communication, Mr. Tesfay Mirach, dairy farmer in Keren). According to

Zeggu (1997) during the 1940's and 1950's, the traditional system was supplying a large quantity of milk. Much milk brought into urban centres was rejected due to poor keeping quality as a sequel to the low standard of production, collection and cooling systems. According to Eldo Infante (1947) out of the total rejected milk brought to Keren from the western lowlands 80%, 9.7%, 9.8%, 0.4% were rejected due to acidity, bad odour, uncleanness, and adulteration, respectively. Table 1.4 shows total milk received, pasteurised and rejected in Eritrea from 1941-1945.

Table 1. 4 Milk (Litres) Collected and pasteurised in Eritrea, 1941-1945

	Total milk	Source				
Year	received	Traditional	Modern	Pasteurised	Sold	Reject
1941	152500	48900	103600	109400	All	43100
1942	754016	690957	63050	578302	"	175714
1943	815129	786266	28863	529850	"	275279
1944	1931516	1505305	426211	1450823	"	480693
1945	2887442	1129528	1057904	2012766	1763284	274682

Source: Rassegna Tecnica delle Industrie Eritreo Eldo Infante, 1947

Since its establishment Italians privately owned the milk processing plant until it was taken over by the Dairy Farmers Association in 1969. Similarly a privately owned pork and milk processing plant called "*Salmuficio Torinoze*" was established to process pork and milk. Milk was processed to different types of products (cheeses, yoghurt, etc.), which were sold mainly in the capital and provincial towns in Eritrea and Ethiopia. These products also had a good market in the nearby countries of the Middle East, Yemen and Djibouti.

This period witnessed the formation of an association called *"Conserzio Technico"* comprising of 21 Italian dairy farmers. This was probably the important take-off point in the development history of the dairy sub-sector in Eritrea. Another important development was the transformation of the association into a larger association called "*Conserzio Zootechnico del Eritrea*" comprising of an even larger population of Italian livestock farmers (not only dairy farmers). Later, some Eritrean nationals joined the association and changed its name to

Eritrean Agricultural Association, "*Conserzio Agricultura Eritrea*" with the objective of assisting and encouraging member farmers with milk sales and input supply, including feed.

At the end of World War II when the Italian rule was replaced by the British and later by the Ethiopian rule, the former Italian owned dairy farms were operating normally under their original owners. Until the military government of Ethiopia came to power in 1975 and nationalised all privately owned big farms and processing plants, the association owned the milk-pasteurising factory and a feed milling plant. However, with the escalation of war following the military rule, farmers at best lost their animals, but frequently were killed by the Ethiopian army. In addition a significant number of animals died because of starvation as a result of successive drought years. Because of these and the nationalisation policy of the Ethiopian government, the association ceased to function. According to Zeggu (1997), the decline of the dairy sub-sector in Eritrea was initiated by the intensification of the liberation war during 1975, which destroyed most dairy farms resulting in the collapse of the commercial dairy industry in peri-urban Eritrea. During the early 1980's when the war was at its climax, a few remaining dairy herds had to seek refuge and hide inside towns as part of the owner households. The dairy farmers' union, the milk processing plants and quality control institutions were dissolved, and naturally were succeeded by direct sale of raw milk to consumers.

Teclu (1995) records that about 57 dairy farmers in and around Asmara who survived the war and drought formed, in 1979, an association under the name Asmara and Surrounding Modern Dairy Farmers Co-operative Association (ASMDFCA) with the objective of working together in the selling of milk and getting feed and other services. The association marketed milk produced by member farmers to a state-owned milk-processing plant named "Ethiopian Milk Pasteurising Plant"(EMPP). The EMPP monopolised the cattle feed by-products from agro-industries. By-products (such as wheat flour by-products from the Red Sea Flourmills Factory, oil seed cakes from the National Edible Oil Factory, brewery by-product from the Asmara Brewery) were sold to dairy farmers only by the EMPP. In order to encourage milk sale to the plant the amount of feed sold to a farmer was based on the amount of milk a farmer sold to the plant.

The occupation of the port of Massawa by the Eritrean Peoples Liberation Front (EPLF) in 1990 and the severe drought during that time caused severe feed shortage. During this period the dairy industry was heavily affected because the external supply of industrial raw materials to most factories in Eritrea was brought to an end and there was no source of supplement. Consequently, death due to starvation was common among dairy animals. The association (ASMDFCA) stopped all operations until it re-established itself after Eritrea gained independence in 1991. It was only in November 1992 that the association re-started supplying milk to the milk processing plant, which was also closed till then. Even though there is insufficient data on the national herd population dynamics, Figure 1.2 indicates how the dairy herd in and around Asmara changed during the1990's.

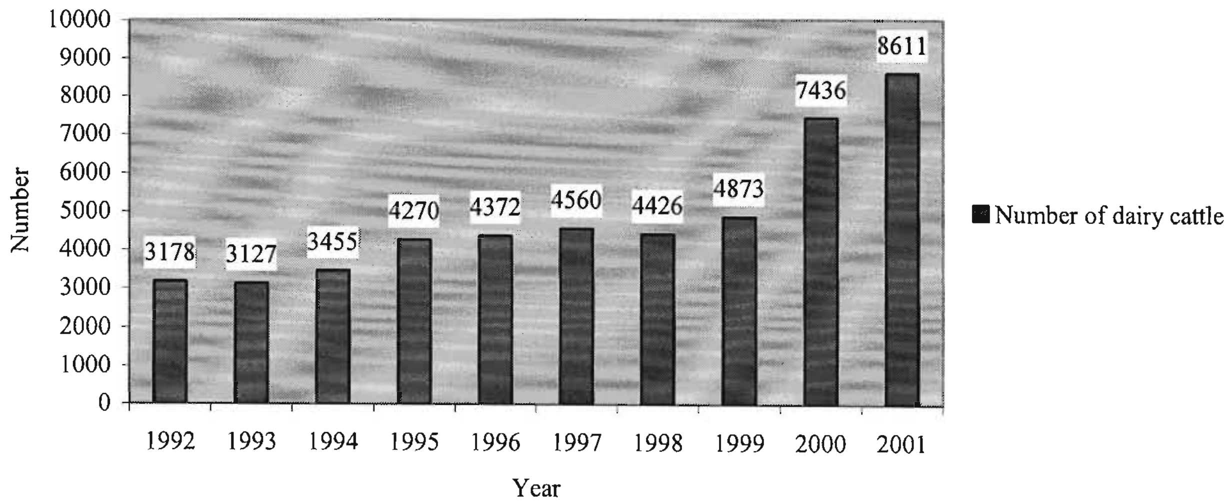

Figure 1. 2 ASMDFCA, Number of dairy cattle 1992-2001

1.2.1 Artificial Insemination Service In Eritrea

Artificial insemination (AI) was introduced to Asmara, Eritrea in 1938 by the Italians for research purpose at the Veterinary Institute. These AI activities were soon suspended because of the outbreak of World War II, only to re-commence in 1952 with success in two progressive farms (Elabered and Meresani). In 1957 the importation of semen and AI ceased for economic reasons until the late 1960's, which saw the re-establishment of an AI scheme in and around Asmara. It came into operation in 1969 as a two-year AI program sponsored by the British Government, Ministry of Overseas Development Project (UKODP). Semen (frozen semen in straw and pelleted form) of Holstein-Friesian breed was imported from the United Kingdom and Greece (Abraham, 2002 personal communication). The program continued with great success until 1975. During the period 1975 to 1980 the AI service was not active.

The Ethiopian Ministry of Agriculture rehabilitated the Artificial Insemination scheme in 1982 by establishing the Kaliti Artificial Insemination Centre in Addis Ababa, Ethiopia. This gave a good chance for the rehabilitation of the AI service in Eritrea. After Eritrean independence (in 1991) the AI service stopped momentarily before restarting using Friesian semen imported from Sudan. Immediately after the declaration of Eritrean independence the MoA began to import Friesian semen from Ethiopia (and Siemental semen from Germany) until the escalation of the border conflict between the two countries. Since then semen has been imported from the Republic of South Africa and Denmark. Currently most of the AI centres are not functioning, with the exception of the Asmara and Elabered Estate.

According to Abraham (2002), since AI service was fully introduced to dairy farmers in Eritrea with the support of different organisations the achievements of AI service (average number of inseminations/calf/year) can be summarised as shown in Figure 1.3.

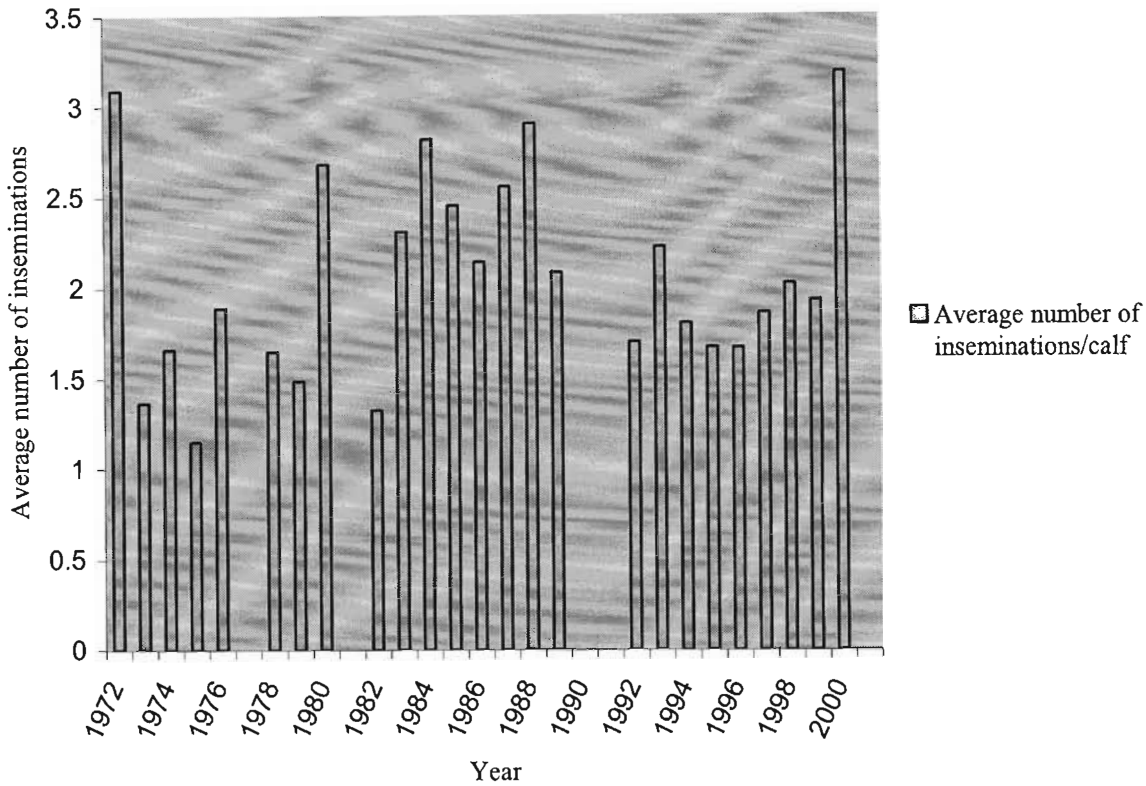

Figure 1. 3 Average number of inseminations/calf/year in Eritrea (1972-2001)

The trend of the AI service could be divided into four phases based on the service years (Figure 1.4). The first phase was 1972-1976, the time when highly effective inseminations (calves/cow %) were recorded. In 1978-1980 the achievement declined but the numbers of calves born and effective inseminations were high as compared to phase one. From 1982-1989 the activity increased, with effective inseminations ranging from 48-75.3%. In phase four, from 1992-2000 the effective inseminations ranged from as low as 31.3% up to 58.8%.

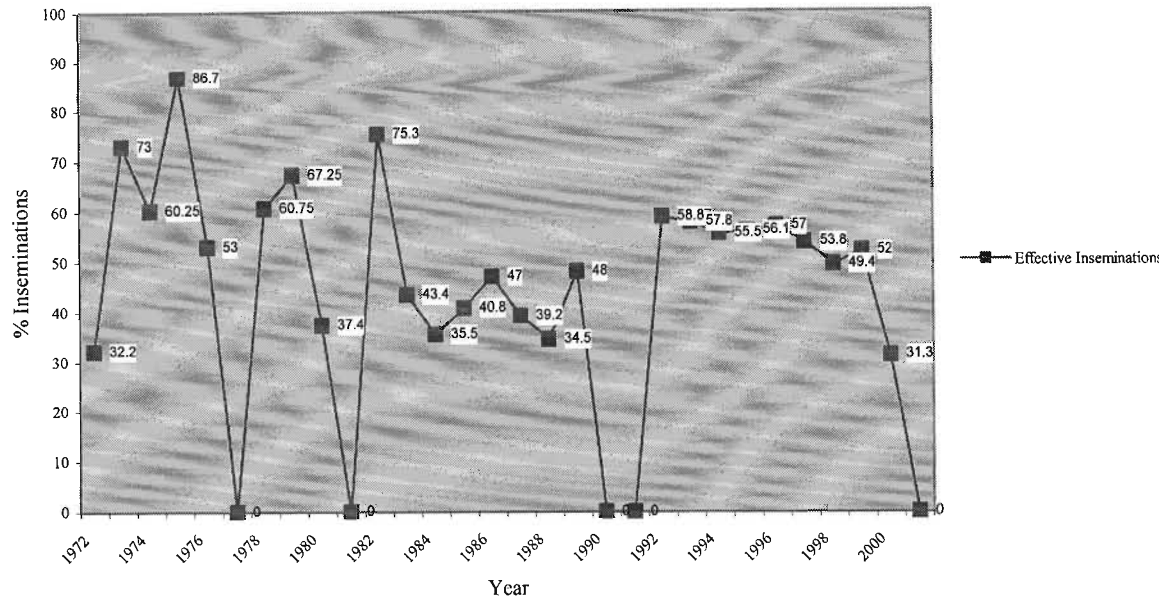

Figure 1.4 Effective inseminations over time

Year-round breeding occurs on farms because most dairy cattle are managed indoors. Most farmers detect heat 2-3 times a day in the mornings and evenings. The actual insemination time is on average 12 hrs after heat is detected, i.e. a cow that comes into heat in the morning is inseminated late afternoon and if she comes into heat in the afternoon she is inseminated next morning before mid-day (Abraham, 2002 personal communication). AI services are paid for, with a charge per service within the range of 20-40 Nfa. Currently a charge of 40 Nfa is levied per insemination at the first service but the cow is given two free inseminations if she repeats the cycle. Three types of requests for insemination service were most commonly practised (Abraham, 2002 personal communication):

The Call base system is practised mostly in the urban centres where the system of communication is well developed. The communication is via telephone; the AI technician goes directly to the farm once he receives the detailed information. **The Daily run system** involved a daily visit to the peasant associations and dairy farms found on the periphery of town. **The Permanent or static base system** was practised on the state farms on a permanent basis where the inseminator was stationed and served there. At present, due to a shortage of AI technicians, only a call based service is practised in the urban areas. The permanent base AI service is only practiced on the Elabered Estate private farm. The main AI centre is located in Asmara where the liquid nitrogen plant and main semen storage facility and a recently established semen laboratory are found. The other centres are located in the main dairy areas, including Dekmhare and Mendefera (in the Southern zone) and Keren in Anseba zone. About 30% of the dairy farmers nation-wide use artificial insemination services (Abraham, 2002).

The main AI centre is equipped with a plant for producing liquid nitrogen, a pickup vehicle and a motorcycle. Other AI centres have containers for storing liquid nitrogen and a motorcycle as a means of transport. The number of AI technicians varied through time, which affected the consistency and capacity of the service (Table 1.5).

Table 1.5 Estimated effective inseminations in Eritrea

Year	Number of inseminators (Y)	No of AIs (X)	AIs/tech. (X/Y)	Effective AI (%)
1971	3	2710	903	32.30
1977	5	0	0	0.00
1980	5	265	53	37.40
1993	8	784	98	57.80
1998	11	592	54	49.40
1999	7	626	89	52.00
2000 to date	3	319	106	31.30

Source: MoA (ARD) Eritrea

Table 1.5 indicates that the efficiency of the AI service was high when the number of inseminators was high, i.e. effective insemination increased with the increase in the number of AI technicians. The highest achievements were recorded during the years 1993, 1998 and 1999. The present number of AI technicians is very low, owing to the on-going human resources capacity development program, which granted most technicians the opportunity to undertake further studies. The centres are operating only with one senior technician located in the central AI station and two other technicians (one at the Southern zone and one at Anseba zone).

1.3 SMALL SCALE DAIRYING ROLES, CONSTRAINTS, OPPORTUNITIES

Dairy production systems range from large-scale, intensive, vertically integrated commercial systems to smallholder `subsistence-plus' income systems (Egan, 1999). Small-scale dairying is an important agricultural activity in many parts of the developing world, producing a valuable food product and providing regular income and work for poor households. However, dairying suffers the disadvantage of requiring a substantial capital investment in cattle and thus involves considerable risk. Given that cattle kept for dairy purposes are almost always exotic crossbreds which are susceptible to a wide variety of disease and parasitism, the investment must be protected by costly preventive measures, both in terms of husbandry methods employed and pharmacological and immunological interventions. Such measures add considerably to the costs of producing milk and restrict the growth of the dairy enterprise. A further emerging threat is the possible occurrence of zoonoses, in particular bovine tuberculosis, and the occurrence of antibiotic residues in milk. As most milk is sold untreated, and to consumers whose immune systems may be already compromised by other disease challenges, further information on the disease status of the dairy cow population is imperative.

If successful, smallholder dairying could provide regular income and year-round employment for rural people, and might counteract rural migration and reduce growth of urban slums (Bachmann, 1985a,b; Kuranaratne and Wagstaff 1985; Walshe *et al.,* 1991). It could also be a means of intensifying land use where land is a limiting resource. As smallholder systems tend to be very labour intensive and high yielding, improved animals are essential. In addition to disease prevention measures, a provision of secure, year-round feed supply, which is appropriately balanced, is needed in order to maximize productivity. It is important to emphasize that the success of such systems depends on the adoption of a complete package, i.e. the various interdependent components of the system are all essential for sustaining high production.

1.3.1 Characteristics of Smallholder Production Systems

In general, dairy production can be divided into three sectors: the large-scale commercial sector, in which cattle are kept purely to generate income; the small-scale commercial sector, in which income and nutrition are the main reasons for keeping cattle; and the traditional sector, in which income is very much secondary to meeting nutritional needs, storing of wealth, providing security and meeting social and cultural functions. Each of these sectors has its distinctive characteristics. The basis of characterisation could differ from place to place depending on the system. A variety of highly productive small-scale intensive mixed farming systems have developed in East Africa, almost exclusively in areas of high population density where agricultural holdings have become too small to support traditional farming practices (Brian, 1990).

According to Walshe *et al.* (1991), about five dairy production systems are identified and characterised in Sub-Saharan Africa (SSA) based on factors such as farmer's priority, attitude of farmers, species of animals used, feed resources, farmers' ability, type of enterprise, milk production, land area per animal, milk density, inputs used, main constraints and potential for commercialisation. Characterisation of the existing production systems for dairy production has an advantage in that it could help to decide what kind of interventions to adopt in order to improve the system, as well as to devise strategies to overcome farming constraints.

The small-scale peri-urban dairy farms found in many countries are basically characterised as commercial. The priority of farmers is to produce milk for sale as a source of income. They use local, crossbred or exotic cattle. Cattle are fed on purchased roughage and concentrates. This is a continuous means of producing a reasonable amount of milk per cow per day throughout the lactation period. In most cases the small-scale dairy is characterised as a low input enterprise, sustained basically using inputs such as concentrate, purchased roughage, breeding and veterinary services. The system is constrained by nutrition, genetic potential or breed, marketing or infrastructure, and extension services. Swai *et al.* (1992) reported that the Tanzanian livestock production system at the farm level has evolved through a long process of finding the best match and combination between production systems and climate, feed, labour and capital resources, market and technology use.

The production systems in East and Southern Africa vary in character depending on the climatic condition and agro-ecological region (Abate *et al.,* 1992). They are characterised as stall-feeding, planted and sometimes irrigated pasture plots or rows for feeding ruminants. All manure is spread on crop and pasture plots while crop residues and weeds, etc are collected and fed and/or conserved for feeding. All these operations are labour intensive. Livestock production thus competes with crops (food and cash) for labour, land, fertiliser and recurrent funds for inputs. The adoption of technologies such as improved livestock breeds (e.g. dairy cattle for milk production) and improved feeding, disease control and management are crucial to promote both productivity and efficiency. While all components are important and must be 'sold' in a package, feeding is the single most expensive item and therefore deserves particular attention (Abate *et al.*, 1992).

Dairy development is encouraged in most developing countries for several reasons: to meet the increasing local demand for milk; to improve the nutrition of the urban poor as milk is the most important source of both protein and energy, followed by meat from cattle and fish; to supplement the incomes of the rural poor; to reduce reliance on imported dairy products and to encourage rural development and services (Payne and Wilson, 1999). The gap between the demand and supply of milk could be bridged by identifying the constraining factors, using appropriate technology and utilizing the potential for development. According to McDowell (1981), identification of constraints and appropriate technology is required for growth of small farms.

In Kenya, peri-urban dairy units have been flourishing and have been described as the major development success story occurring in Sub-Saharan Africa (Staal and Shapiro, 1994). Productivity of these units has been sufficiently high to more or less keep pace with increasing demand for milk and milk products in Kenya and probably accounts, to a large extent, for the low level of Kenya's dairy imports compared to other sub-Saharan African countries (Olaloku *et al.*, 1990).

Dairy units located within or close to major cities have herd sizes of about 10 cows, kept under an intensive zero-grazing regime. Financial inputs go towards the purchase of improved crossbred animals, production of farm-grown fodder where land is available, purchase of supplementary feeds and payment for veterinary services and hired labour if and when needed. Milk is marketed through formal and organised co-operatives, as well as through informal channels to local traders and individual consumers.

Herd management determines the production potential of producers. Smith and Olaloku (1998), described urban dairy production units in Addis Ababa, Ethiopia as backyard producers because, with limited land holdings, all operations are carried out within family compounds. The animals are fed on roadside grazing supplemented with purchased fodder and concentrates. Performance is rather average in spite of the improved genotypes used. Both large and small-scale producers market their milk mainly through the informal channel, selling directly to individual consumers, institutions, informal processors and traders.

1.3.2 Roles of Small-Scale Dairying

Dairy production constitutes an important source of income through the sale of live animals and animal products. It also gives employment opportunity and is a source of food. Livestock ownership also impacts on farm productivity (through use of animal traction and manure as fertiliser or fuel) and hence cereal food production (Ehui *et al.,* 1998).

Dairying in general, and small-scale dairy farming in particular, can play a vital role in rural and urban population growth and development in many aspects. According to McDowell (1978) small scale farming is described as a unit operated by a single family with little or no outside labour and with returns that provide subsistence but little for savings, capital investment or for the purchase of external agricultural inputs, with significant dependence on livestock. Dairy farming also serves as a source of food and storage of wealth for the farming family.

Income and Employment

Peri-urban livestock production systems, including dairying, play many roles such as the provision of employment and income to the unemployed or low-income urban families, and the provision of supplementary income to the employed, poorly paid, middle class urban dwellers (Smith and Olaloku, 1998).

Jabbar *et al.* (1997), identified the dairy industry as having a number of specific features that distinguishes it from the other sectors of agriculture. It is expressed as a special case in world agriculture. The study further elaborates that the specifics are due to four partly interrelated properties of milk as a raw material bulkiness and weight, continuous production on daily basis which further leads to a high-cost of transportation and limited value. Furthermore, milk is a very perishable product that demands strict keeping and cooling facilities until it is processed and transformed into other more stable products. The socio-economic position of the producers is considered also as the second distinguishing factor. Since milk is produced daily it serves as a regular source of income to most small-scale producers. Furthermore, the dairy sector demands an intensive source of labour both in the production as well as collection, transportation, processing and distribution of milk in a sustainable way. Staal and Shapiro (1996) described the urban and peri-urban dairy production systems among the many forms of dairy production systems in the tropics and sub-tropics, which involve the production, processing and marketing of milk and milk products that are channelled to consumers in urban centres. This makes it highly important for the liveability of rural, urban and peri-urban areas.

Dairy production is becoming a multifunctional economic activity in most rural communities. Another reason for keeping dairy animals is to utilise available resources (land, feed, labour, capital) and to generate income, employment and a supply of milk (Tegegne *et al.* 2000; Thorpe *et al.* 1992). Leegwater *et al.* (1990) and Huss-Ashmore and Curry (1992; cited by Thorpe *et al.*, 1992) reported that by responding to the demand for milk through integrating dairy production into existing smallholder farming systems, incomes can be both increased and stabilised, employment opportunities can be created and household food security can be improved. Increased milk production is also considered as a source of family income.

Small-scale farmers' income-generating power and production ability could be assured by a sustainable and reliable marketing system. A significant amount of the marketed milk supply in most parts of the world comes from producer co-operatives. According to Payne and Wilson (1999), more consistent milk pricing is achieved in the development of the dairy industry in many tropical countries by co-operatives. For instance, experiences from Eritrea have shown that the amount of milk in the capital Asmara supplied by the ASMDFCA during the years 1982-2001 was as follows (Figure 1.5).

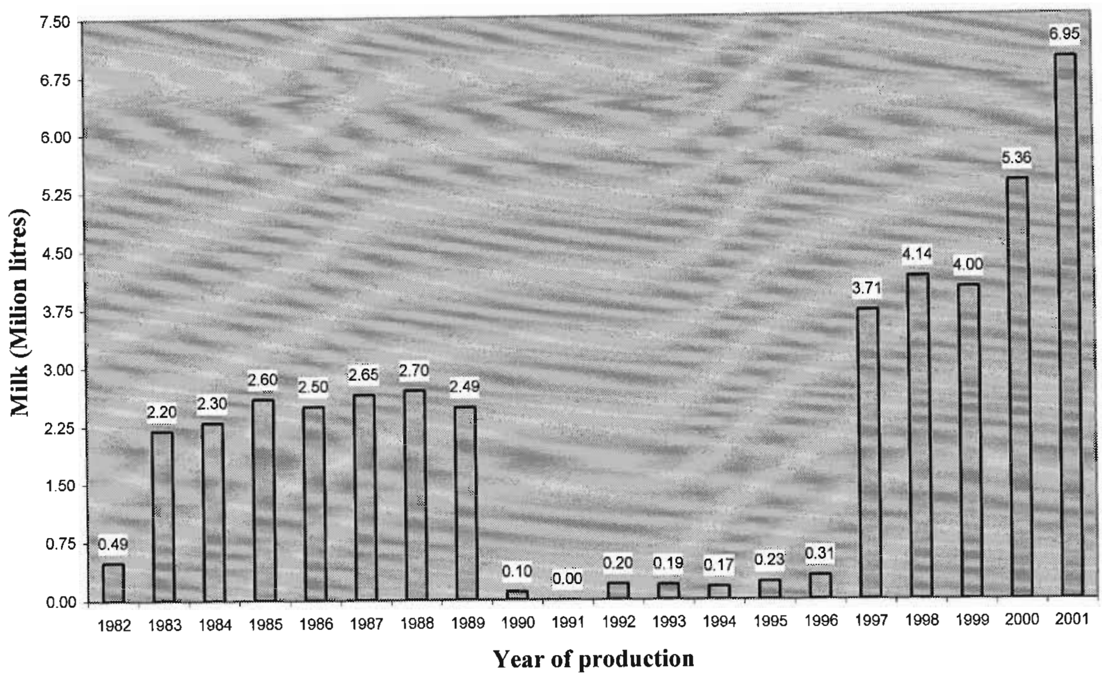

Figure 1. 5 Total milk supplied by ASMDFCA (1982-2001) for marketing in Asmara

Provide Support to Crop Farming

Most farming activities are interrelated and support each other. Small-scale dairy farming also supports crop farming activities by supplying draught power and manure to fertilise the farms. A majority of the animals used by small-scale dairy farmers are pure exotic breeds, or local breeds or crosses of these breeds. According to a study conducted in Ethiopia by Zerbini *et al.* (1995), cross-bred cows can be used as dual purpose animals by the highland farmers: providing a source of milk for the household and draught power for the cultivation of crops during the cropping season. Gryseels and Goe (1984); Gryseels and Anderson (1985); Matthewman (1987); Burton (1991) all cited by Zerbini *et al.* (1995) reported that the use of dairy cows for traction could double the benefit and incomes through milk production when cows are off ploughing season. It is also unnecessary to keep and feed draft oxen year-round and to maintain a follower herd to supply replacement oxen. Rearing of dairy cows as multi-purpose animals has an advantage in that the income of the household could be increased by generating money from the sale of male calves which were supposed to be used for draught power. Farmers' income and purchasing power could be improved as a result of replacing cows for draught power and selling males. According to Zerbini *et al.* (1995), besides contributing to a better utilisation of scarce feed resources, using dairy cows for draught would allow males to be fattened and sold younger, and could also lead to greater security of replacements. Reducing stocking rates and keeping fewer and more productive animals would enable productive and sustainable farming systems.

A shortage of ploughing oxen due to poor economic power of farmers could constrain them from ploughing their lands on time during the cropping season. However, introducing multi-purpose cows to the farming system could solve the problem. Lawrence (1985) and Munzinger (1982) both cited by Brian (1990) reported that traditionally cows in Africa have not been widely used for ploughing, presumably being considered to be too weak. Where animals have been used, oxen have been preferred, which means that their usefulness is limited to the ploughing season, although they must be supplied with feed all year round. However, pairs of well-fed, healthy cows, particularly the large-bodied types, should be quite capable of meeting the draught-power requirements of smallholdings, especially if techniques such as mulching and the recycling of manure have been applied, increasing the organic matter of the soils and thus making them easier to work. Research in countries where a considerable proportion of draught animal power is derived from cows has shown that milk yields (Lawrence, 1985, cited by Brian 1990) and calf growth rates (Munzinger, 1982, cited by Brian 1990) are not significantly reduced, provided that the cows are adequately fed when working.

Source of improved Genetic Material

The genotype of the cow determines the productivity of the dairy farm, provided other conditions have been fulfilled. Small-scale dairy plays another role by introducing crossbred cows that can serve as a source of improved genetic material. The genetic make up of the national herd could be improved by cross breeding using mainly AI or exotic bull service. This potentially could lead to increased productivity. Furthermore, the damage on soils could also be reduced as a result of reduced stocking density since farmers could keep fewer, potentially more productive animals. Generally local cows used by smallholder farmers in the tropics have low genetic potential for milk production but are well adapted to climatic stress while showing a reasonable degree of resistance to endemic diseases. Thus F1 cows arising from crossing these breeds have good adaptation to local conditions while producing more milk than the local breeds.

1.3.3 Constraints to Small Scale Dairying

Small-scale dairy serves as a main source of milk for home consumption as well as for a large majority of local consumers. Dairy development in Sub-Saharan Africa is constrained by environmental (physical and economic), technical and social/institutional factors (Walshe *et al.,* 1991; Devendra 2000). The technical constraints include genetic structure, feed and nutrition, health and disease problems, management, water shortage and appropriate technologies. These constraints provide major opportunities and challenges for research and development to increase dairy production and improve livelihoods of poor farmers. Smith and Olaloku (1998) reported that an adequate supply of institutional support services in terms of credit facilities, health delivery, input supply and distribution, and technical advisory services are all crucial for successful management of peri-urban dairy units. Lack of support services like technical advice, credit facilities, organized markets, seed and fertilizer supplies and suitable equipment have contributed immensely to the low production of small-scale dairy farmers (Payne and Wilson, 1999). Therefore, the future of any dairy operation depends on a successful programme that emphasises efficient and cost-effective methods of production.

Generally, the constraining factors in dairy production systems are more or less similar to other livestock production systems. It is important to have a totally integrated production package that balances all aspects of the production system in order to tackle the constraints to production in the tropics. These constraints could be associated with climatic, nutritional and other environmental variables, inadequacies in the financial system, and deficiencies in the types of managerial skills that are required in improved dairy production systems. Therefore, a clear strategy should be designed to find solutions for these constrains and attain improved production.

Nutrition

Nutrition is the main hindrance to milk production because feed is low either in quality or quantity. Smallholders in developing countries have limited feed resources available for feeding ruminant livestock. They often do not have the luxury of being able to select the basal diet. They use whatever is available at no or low cost. The available resources are essentially low digestible forages such as tropical pastures (both green and mature), straws and other crop residues and agricultural by-products which are generally low in protein. The limited and seasonal supply of feed resources affects the potential and level of productivity of dairy cows. Secondly, improper/lack of balance of nutrients affects productivity. Furthermore the interaction between nutrition and reproductive activity can impact on milk production in the lactating cow. During lactation, the length of time spent in negative energy balance after parturition seems to be an important factor controlling the delay to return to breeding (Blache, 2000).

The productivity of animals is affected by the quality of feed supplied because intake and digestibility are interrelated phenomena in the physiological process of ruminants. Feed supply fluctuates widely in terms of quantity and quality because of poor soil fertility and scant, unreliable and markedly seasonal rainfall (Walshe *et al.,* 1991). Besides seasonal fluctuations in feed supply, McDowell (1978) adds that land for forage production is either restricted or unavailable, the immediate challenge is thus one of finding possible technologies for making more complete use of existing feed resources. Efficient utilisation of forages requires knowledge of the composition and value of specific feeds as sources of protein, energy and minerals.

Knowledge of Farmers

Farmers require knowledge on feeding, health, housing and other important dairy management issues. Inadequate knowledge of appropriate dairy cattle management affects productivity. Poor management mostly results from inadequate knowledge. Poor herd management practices in areas of cow handling, nutrition, milking procedures, sanitation and housing, predispose the individual animal as well as herds to diseases. Although poor herd management may be caused as much by a shortage of labour at critical times as by ignorance or inefficiency, there are often significant gaps in livestock owners' knowledge, especially about causes of disease and new technical possibilities (Walshe *et al.,* 1991). Herd management decisions taken by herd managers or cattle owners have positive impacts in reducing health problems. Thus, optimum production and profitability could be achieved through good herd management practices and effective disease prevention programmes.

Efficient herd management cannot be achieved without efficient feed management, however the conceptual separation of herd management from feed management helps assess what income effects could be expected from better herd management alone.

Animal Health

Although the environmental constraints most difficult to deal with are those related to the climate and feed resources, internal and external parasites along with some bacterial and viral diseases must also be considered in smallholder production systems. In situations where parasites are a problem, the local breeds are likely to be more resistant to the parasites. *Bos indicus* breeds carry fewer ticks than *Bos taurus* breeds and they are also more resistant to the species of gastrointestinal helminths that prevail in the tropics than exotic breeds. Because of their resistance to parasites, local breeds are very important in the development of a smallholder dairy industry. In any crossbreeding program the local breeds will be the base populations that will confer the resistance traits required in the early stages when a local breed enters an up-grading program for a particular production trait.

Tropical climates add stresses that compound health problems and increase the incidence of disease. Stress can be minimised through good housing and care, thereby reducing the risk of disease. Likewise, limiting the percentage of *Bos taurus* blood in crossbreeds of smallholders reduces the need for sophisticated management and facilities.

Milk production demands hygienic and healthy animals that are free of any contagious as well as infectious diseases. This depends on the availability of effective and efficient animal health services. An inefficient and poor animal health service is associated with a high incidence of infected animals. Some zoonotic diseases like brucellosis and tuberculosis can be transmitted to humans through the consumption of milk or milk products containing the pathogen. The incidences of bovine TB and Brucellosis on Eritrean dairy farms is summarised in Table 1.6.

Table 1.6 Bovine Tuberculosis and Brucellosis Test Results, from Dairy Farms in Eritrea

	Dairy cattle tested		Results					
	(Nos)		TB			Brucella		
Area	TB	Br.	-ve	+ve	%+ve	-ve	+ve	%+ve
Asmara	1979	1979	1658	321	16.20	1915	64	3.20
Mendefera	470	470	448	22	4.50	469	1	0.21
Dekemhare	262	262	260	2	0.76	262	0	0.00
Keren	130	74	130	0	0.00	74	0	0.00
Elebered	602	436	601	1	1.16	435	1	0.23

Source: ARD, MoA (1996-97)

Another cause of poor animal health is the low supply/lack of medicaments. If there is no proper or regular supply of veterinary drugs there will be high chance or degree of animal disease resulting in low milk production. In tropical areas, high incidence of disease occurs due to poor delivery of veterinary services and is a serious barrier to animal productivity by complicating the health situation of animals (Smith and Olaloku, 1998). Available services are thinly spread and ineffective, as are drug availability and distribution. Constraints to the successful control of diseases are not technological but related to the availability and cost of treatment. Developed and improved milk marketing infrastructures could improve income and purchasing power of dairy farmers, as a result the provision of vaccines and antibiotics will become more prevalent and more affordable to smallholders.

Breed or Genotype

Breed/genetic make-up of animals has great impact on the productivity of the animals. Poorly kept breeding records; low level of selection and lack of research contributes to low genetic improvement of dairy animals. Record keeping is an indispensable component of modern dairy farming, but is usually non-existent on most smallholder farms. Sometimes the animals are identified only by name and this could be confusing, even to the farmer. Low genetic potential of dairy cattle, which is mostly due to lack of proper selection, lack of and/or no research and inbreeding, result in low milk production. According to Walshe *et al.* (1991), indigenous cattle and other livestock have been selected for their survivability rather than their productivity, thus marketed output is relatively low.

Anteneh *et al.* (1988), cited by Walshe *et al.* (1991), reported that the proportion of Sub-Saharan Africa's total cattle herd significantly affected by deliberate genetic change is probably less than 3% or 5 million head. Thus the genetic structure has evolved largely as a result of natural selection influenced by environmental factors for survival under high disease challenge and fluctuating feed and water supplies, rather than for high levels of production. Among indigenous cattle breeds in the tropics, only a few breeds have good milk potential as they are mostly multipurpose (milk, meat, draught) animals. According to Smith and Olaloku (1998), many local indigenous breeds of cattle have developed adaptive traits for disease resistance, heat tolerance and ability to utilize poor quality feeds. This adaptation to the natural environment is often not accompanied by high performance traits.

According to Pedersen and Madsen (1998), production traits of indigenous cattle could be improved through different methods that included selection within the existing population and crossbreeding with exotic breeds. The level of reproductive management in cattle influenced the cows' individual production as a result of adaptation to the existing environmental condition. It is easy and practical to do selection in a properly managed herd. Selection plays a role in the development of dairy herd productivity. Syrstad (1991), cited by Pedersen and Madsen (1998), reported that selection within the existing population has the advantage of ensuring the development of animals that are able to adapt well to the existing feeding and management systems. The study further clarifies that hardly any selection has until now taken place within local populations in the tropics, but that should be good prospects for improving the production potentials of tropical breeds as that of exotic breeds.

The genotype of animals that are raised in smallholdings must be compatible with the environment and the available resources, including the knowledge and skills of the farmers. Thus cows must be served with bulls or semen of the appropriate genotype and replacement stock must be selected based on defined criteria. To avoid in-breeding, strong extension services, well-organised AI organisations, and co-operatives are required to provide the necessary information to smallholders. According to a study conducted on dairy cattle in Cameroon, increased milk output not only depends on the levels of feeding but also on the genetic potential of the cow (Tambi, 1999).

As efforts are made to improve the productivity of cattle for milk production, it has become increasingly clear that the genetic potential of many local breeds is extremely limited. Genetic progress in cattle is slow, and with the increasing demand for high-quality protein foods by the population, cattle breeders must intensify their efforts to develop a highly efficient milk-beef herd. The feasibility of this, however, depends on the genetic merits of dairy animals and the extent to which efficiency in breeding can be achieved. The identified major disadvantages of dairy production in Cameroon are late sexual maturity (age at first calving), long calving intervals and short lactation lengths for the local zebu (White and Red Fulani), and high mortality rates for the pure exotic breeds (Holstein-Friesians and Jerseys) (Tambi, 1999). Contrasting with the performance of European and American breeds kept in temperate climates, crosses between the exotics and local zebus have frequently shown a relatively low productive and reproductive efficiency under tropical conditions (Lemka *et al.*, 1973). However, with available good quality feed, standard management and favourable climate the optimum level of exotic blood would be around 50% (Brian, 1990).

Farmers have indigenous knowledge for breed preference and that should not be ignored because any breed has its own adaptation potential to a given condition. For instance, breed preference varies depending on location of Ethiopian dairy farms (Table 1.7)

Table 1.7 Breed Preference by Farmers in Ethiopia

	Dairy Farmers by Location		
Breed	Secondary towns	Peri-urban	Urban
Grade/cross bred	85%	67%	44%
Pure exotic	10%	33%	56%

Source: Tegegne *et al.* (2000)

Tegegne *et al.* (2000) also reported that about 92% of urban farmers produce their own animals through crossbreeding zebu cows with exotic bulls. Purchase of heifers or cows from other dairy farms is the main source of replacement for 29% of the farmers in secondary towns and 17% in peri-urban areas. Although the selection criteria of animals vary, milk yield potential, reproductive efficiency, disease resistance, breed or body size are the most important criteria for bull selection.

Marketing

Small-scale dairying serves as a source of income to a vast farming community through sale of farm products to fulfil family needs. Sustainable income generation can be achieved if and only if there is an organised marketing system. According to De Boer (1981), development of economically viable and socially acceptable dairy production systems in developing countries requires simultaneous consideration of production, distribution, and pricing aspects. An efficient collection and distribution system of milk from the farmer to the consumer is a critical factor in dairy development because the success of any dairy enterprise relies on access to market (Tesfaye, 1992). Participation of smallholder farmers is essential in the supply and distribution of marketed milk to consumers through a channelled marketing system. Both the producers as well as consumers of the supplied product could benefit from a channelled marketing system. Brumby and Gryseels (1984), cited by Tesfaye (1992), reported that smallholder participation flourished in dairy development projects where milk collection and cooling centres had been established to cater for consumers. In the highland and sub-humid areas of Ethiopia, marketing and pricing of milk have not posed any problem. Farmers in the highlands prefer the traditional marketing system in which milk and milk products are sold directly to consumers at a negotiated price which is generally higher than that offered by the Dairy Development Enterprise (DDE). In the sub-humid zone, because of the distance from the collection schemes, farmers relied on the traditional processing system (Tesfaye, 1992).

Similar schemes have been successful in other African countries where small-scale holders of some regions have for many years supplied others with milk. In Malawi the marketing of milk from traditional herds close to centres of consumption has been accepted as part of development strategies for that country (Agyemang and Nkhonjera 1986; Walshe, 1990). In

Ethiopia, most milk and dairy marketing occurs through the informal sector. Small-scale producers supply almost 88% of all urban milk as raw milk through the informal market. Few large farms or collective marketing organisations exist, but the bulk of marketing is of small-scale type. The DDE, which acts as a buyer of last resort, handles only 12% of urban milk supply and pays the lowest average prices. Thus, direct sales by producers to individual and institutional consumers, bypassing the dairy parastatal and private middlemen, constitutes the bulk of milk sales in the Addis Ababa milk shed. In this environment both producers and consumers of dairy products appear to put a premium on contracting with only a small number of clients/suppliers, suggesting that transaction costs could be especially high in open milk markets. Overall, smallholder dairy producers appear to generally face higher transaction costs than large-scale producers. Prices decrease with distance and vary depending on the size of sales and flexibility of contractual relationships between producer and consumer. In some marketing channels smaller producers receive lower prices than large-scale producers.

1.3.4 Opportunities

In terms of opportunity, dairying is admirably placed across the whole range of agricultural developments to raise and sustain livelihoods and the economic well being of participating households. From a socio-economic point of view, the introduction of dairying can be entirely linked to poverty alleviation in the rural areas. As a tool for rural development, dairying can simultaneously improve the nutrition and health of all members of the household. In addition, and quite crucial from a national perspective, market supplies of milk products increase and the demand for the labour and services of the poor is enhanced through the creation of growth in the dairying sub-sector. Small-scale dairying could lead to a sustained use of resources in its stage of development and growth. Smallholder dairy systems make a socio-economic impact on poverty alleviation by utilising resources to increase production of high quality food (Egan, 1999).

Sustainability in such a system consequently creates complex political, socio-economic, educational, and technical questions. The expected outcomes of the system are improved farmer lifestyle, meeting of community needs, efficient utilisation of resources, optimisation of feed base production, undegraded land and water resources, high conversion efficiency of livestock, effective and reliable product output meeting demand and quality specifications, and sustained land-use capability. Sustainability and efficiency of small-scale dairying could be measured not only by the production size but also by the viability of the system. Viability depends on the size or amount of input injected into a system and the size of output obtained as a result of the intervention made to it.

Smallholder production can begin to form the basis of a commercial dairy industry and a number of smallholder milk schemes have been initiated with varying degrees of success (Matthewman, 1993). The development of smallholder milk production schemes requires different forms of interventions. These could be in the form of support services as well as different extension packages. Producers' potential could be expressed by their use of feed resources, improved system of management, grade cattle as well as organised milk marketing system. According to Matthewman (1993), there is considerable potential for development of smallholder dairy systems for diversification and increased production. Therefore, a sustainable and profitable dairy could be achieved by high levels of management such as appropriate feeding, health care, and reproductive management (Tegegne *et al.*, 2000).

Generally, the level of planning and technical and economic feasibility determines the potential of any production system. Available land for forage production and housing, good extension and farmers' advisory services, and supply of necessary inputs and veterinary drugs could be worth mentioning as common criteria designed for guaranteed milk price.

In summary, this review discussed the multi-faceted role played by small-scale dairy production. Milk supply is one among the roles of milk related to nutrition of the community. Milk supply in Eritrea mostly comes from the small-scale dairy farmers found in and around Asmara. It significantly contributes to meet the growing demand for milk and other dairy products by the population. As a result of urbanisation and increasing urban population, demand for milk increased while supply is low. For instance, in Asmara the estimated population is about 400-450 thousands and the total milk supplied by the Asmara and Surrounding Modern Dairy Farmers Co-operative Association (ASMDFCA) during 2001 was about 6.9 million litres, including Elabered dairy supplying about 2000 litres of milk per day. The daily milk supply is about 20,000 litres and the theoretical milk available per capita per day is in the range of 40-50 ml, which is about 50% lower than 93 ml/person/day in the highlands of Sub-Saharan Africa (Table 1.8). This could indicate that there is a shortfall of 40 ml/person/day as compared to SSA countries. Therefore, if the gap in milk production is to be filled, research should be conducted to assess the problems impeding dairy production.

Table 1.8 Livestock, land and milk production in Sub-Saharan Africa

	Arid/semi-arid	Sub humid/humid	Highland
AU/person	0.26	0.10	25.1
Grazing, ha/AU*	10.1	7.4	4.6
Crops, ha/AU	1.1	2.3	0.8
Milk, kg/AU	191	76	135
Kg/person	49	8	34**
Kg/ha	17	10	25

Source: Sere, C. and Steinfeld, H. 1996

*Animal unit

** Total milk produced per person in highland of SSA related to the percapita consumption per person in the highlands of Eritrea.

1.4 OBJECTIVES OF THE STUDY

The imbalance between supply and demand of milk in Eritrea could be the result of different, unidentified technical, social as well as economic factors. The overall objective of the study was to assess the existing situation of the dairy sub-sector in Eritrea, with special emphasis on Asmara and surrounding dairy farms. The specific objectives were:

- To assess the historical background of the dairy sub-sector in Eritrea.
- To identify the major problems constraining the dairy sub-sector.

CHAPTER TWO

A SURVEY OF URBAN AND PERI – URBAN DAIRY FARMS IN AND AROUND ASMARA, ERITREA

Abstract

The objective of the study was to analyse the historical background and identify constraints of the dairy sub-sector in Eritrea. The population of interest consisted of dairy farmers located in and around the capital Asmara. Thirty dairy farmers were randomly selected and interviewed. Data on herd composition and breed, type and source of feed, type of mating, dairy housing, health, farmers' status, milk production and marketing, problems and constraints faced by dairy farmers were collected. Secondary data obtained from ASMDFCA were also subjected to cluster analysis to classify farmers according to their characteristic features (profile characteristics). Farmers were grouped with farmers of the same character. Interviewed farmers were characterised based on location, herd size, health, and farmers' status. Average herd size and lactation length were 15.4±11 animals and 6-7 months, respectively. Common feed types used in the study area were cultivated forage, purchased forage, vegetable waste, grazing, hay/straw, industrial by-product, and compound feeds. Dairy farmers vary in their access to forage. A high proportion of peri-urban farmers has access to cultivated forage while a large proportion of urban farmers has access to purchased forage. Usage of cultivated and purchased forage was associated with location ($p<0.05$). Natural, AI and combined systems of mating were used by 86.7%, 3.3%, and 10% of farmers, respectively. Both urban and peri-urban farmers use in-door systems of housing. Foot and mouth disease (FMD), lumpy skin disease, nutritional disorders, mastitis, abortion, tuberculosis and digital problems were the most prevalent diseases. Dairying was considered by a majority (73%) of farmers as a primary means of income but by 27% as a part time means of earning additional income. A large amount (67%) of milk produced was marketed through formal channels while the rest (23%) was sold directly to consumers. Three clusters with respectively, 47.04%, 45.06% and 7.91% urban and 37.13%, 61.56% and 1.3% peri-urban farmers were identified. Clusters 1, 2, and 3, had 10±0.6, 5±0.5 and 23±1.82 cows, respectively and produced 49.7±3.45kg, 24.3±3.02kg and 117±10.73 kg of milk/farm/day. Shortage of land and feed, and lack of co-ordination were

identified as major constraints facing dairy farmers. This study revealed that there is need for dairy development in Eritrea. Provided the identified constraints are solved, the existing potential could be exploited. It was concluded that there is a need for further research.
Key words: cluster, dairy systems, constraints

2.1 INTRODUCTION

The commercial dairy farms in Eritrea are principally located in and around the main urban centres of the Highland Ecological Zone. These dairies supply fresh milk to the urban centres. Since its introduction until the mid 1970's the modern dairy industry grew at a steady rate. Most dairy farms were located outside the main urban centres and animals were fed cultivated forage. Land was available for forage cultivation in most dairy farms. However, with the escalation of the war of liberation most dairies relocated to the city centres where it was safe. War destroyed infrastructures and caused dairy cattle to die of starvation. The nationalisation policy of the former Ethiopian socialist military regime also contributed to the decline of the dairy sub-sector.

Dairy cattle population and distribution are mostly related to milk market and feed availability. A majority of dairy farmers that relocated towards urban centres did not return to their former properties but had to depend entirely on industrial by-products to feed their cattle. The number of dairy cattle decreased as a result of feed shortage and improper housing. This led to decreased milk production, uneven distribution and unsustainable processing. Due to the change in management system, direct sale of milk to immediate consumers in the locality became common.

The major urban and peri-urban areas accommodating the dairy farms are geographically grouped into areas of the highland ecological zone namely: Asmara, Mendefera, Dekemhare and Keren. The dairy sub-sector started to revive gradually after independence. Factors limiting dairy farming are not well identified. Assessment and investigation of the characteristic features of the existing production systems could help to identify the problems. Therefore, the objective of this study was to analyse anecdotal and current data (information) in order to identify dairy farming constraints in Eritrea.

2.2 MATERIALS AND METHODS

The study Area

The study was conducted in the Zoba Meakel Administrative zone located in the central highland ecological zone of Eritrea. Three Sub zobas namely Asmara city, *Gala-Nefhi*, and *Beriqk* were included in the study. The population of interest consisted of dairy farmers located in and around the capital Asmara.

A questionnaire survey of qualitative and quantitative nature was used to collect data. The instruments employed for data collections were interviews, formal and informal discussions, personal observations, and group survey. Time allocated for the study was three months including travel days and time used for arrangements. The study was conducted from January to mid March 2002.

A questionnaire was prepared prior to the departure of the researcher to Eritrea. On arrival in Eritrea, the researcher reported to the Human Resources Development (HRD) office at the University of Asmara to discuss the research proposal and how to proceed with it. Several discussions were conducted with collaborative institutions such as the Ministry of Agriculture, Animal Resources Department (MoA-ARD), Asmara and Surrounding Modern Dairy Farmers Co-operative Association (ASMDFCA) office, and private livestock consultants to get a clear view of the study. Accordingly, a time plan was prepared for conducting field survey and farm visits.

Thirty dairy farmers from Asmara and surrounding areas were randomly selected from the list provided by the ASMDFCA office. They were 15 farmers from Asmara City, 13 from *Beriqh* and 2 from *Gala Nefhi* sub zones. The survey was conducted by the researcher in co-operation with ASMDFCA who assisted by supplying a list of dairy farmers and informing them with the aid of a letter about the objective of the study, prior to the date of interview. Fifteen dairy farmers were also participated in the group survey.

2.2.1 Data Collection

Data were collected from primary and secondary sources of information.

2.2.1.1 Primary data collection

Questionnaire

Primary data were collected using a structured questionnaire (Annex i). Appointments were made with dairy farmers prior to the day of interview, requesting them to stay at their farms. Farmers were interviewed individually. Personal observation was also done on the overall farm situation and condition. The questionnaire was kept as checklist and guide for sequential enquiry by the researcher.

The questionnaire encompassed information on herd composition and breed, type and source of feed, type of mating, dairy housing, health care and incidence of economically important dairy diseases, status of farmers (category), milk production and marketing channels. General farm condition and calf rearing practices, housing structure, location, manure management and disposal were all observed. Finally the major constraints faced by the dairy farmers were assessed.

Group survey

A group survey was conducted to identify the major constraints impeding dairy production. A one day meeting was conducted in February 2002 with 15 dairy farmers representing urban and peri-urban areas. Dialogue, brainstorming, and group discussions were used as guiding principles for the group survey. Open discussions were conducted among farmers themselves, with animal production experts and the advisor from the ASMDFCA as facilitators of the meeting. Farmers listed major on-farm production problems. The identified problems, written on cards, were collected and listed on a board. Thorough discussion followed and the problems were grouped based on their similarities. Pair wise ranking of the identified problems was done using a matrix (Table 2.1). The constraints subjected to pair wise ranking were: (1) feed shortage, (2) lack of co-ordination, (3) lack of skilled manpower, (4) disease and shortage of veterinary drugs, (5) lack of extension package, (6) shortage of land, (7) lack of milk cooling and transport facilities, (8)lack of know-how and (9) inconsistent AI service.

Table 2.1 Pair wise matrix of constraints

	1	2	3	4	5	6	7	8	9	Rank
1	-	0	1	1	1	1	1	1	1	7
2	1	-	1	1	1	0	1	1	1	7
3	1	0	-	0	1	0	1	1	1	5
4	0	0	0	-	1	0	1	0	1	3
5	0	0	0	0	-	0	1	0	1	2
6	1	1	1	1	1	-	1	1	1	8
7	0	0	0	0	0	0	-	0	0	0
8	0	0	0	1	1	0	1	-	0	3
9	0	0	0	0	1	0	1	1	-	3

1: Feed shortage.

2: Lack of co-ordination or linkage among MoA and dairy farmers.

3: Lack of skilled manpower in dairy cattle management.

4: Prevalence of important dairy diseases and shortage of veterinary drugs.

5: Lack of dairy extension package.

6: Shortage of land for dairy housing and forage cultivation.

7: Lack of milk cooling and transport facilities.

8: Lack of know-how on dairying.

9: Inconsistent AI service.

2.2.1.2 Secondary Data

Secondary data were collected from different institutions and libraries such as MoA, ASMDFCA and Asmara Pavoni social centre library, through personal contacts with various individuals. Although there was shortage of published and/or documented reference material on dairy farming in Eritrea, available materials were used in the study. The main source of secondary data that was subjected to analysis comprised 563 dairy farmers and included information on farm identification number, location, breed, herd structure (cows, calves, heifers, bulls), milk yield/farm/day and milk yield/cow/day. The data was obtained from ASMDFCA.

2.2.1.3 Statistical Procedures and Method of Analysis

Secondary data

Data were analysed using Statistical Analysis Systems (SAS version 1987). Correlations were calculated to observe the relationship between pairs of variables. Data of the 563 dairy farms was subjected to cluster analysis and dairy farmers were classified according to their characteristic features (profile characteristics). This technique allows the grouping of individuals into clusters so that individuals in the same cluster are more similar to each other than individuals in other clusters. The first step in clustering was to apply the variable reduction procedure called ACECLUS (Approximate Covariance Estimation for Cluster Analysis) to two variables (number of cows and bulls), which served as indicators of farm production capacity, the output of this procedure being two canonical variables (Can 1 and can 2). Can 1 accounted for 99.8% of the variation and was used for clustering. In the second step, Ward's minimum variance cluster analysis method was used to group farmers in order to ensure that within-cluster differences were minimized and to establish the optimum number of clusters. After eliminating outliers with missing values, three clusters accounting for 89% of the variation, were selected. The validity of the clusters was established using canonical discriminant analysis on variables (bull/cow, calves, calves/100 cows, heifers, milk yield/farm/day and milk yield/cow/day) not used in clustering. Chi-square statistic was used to determine the significance of, or the association between, locations and clusters.

Primary data

Qualitative data obtained from the survey were coded to make them suitable for statistical analysis. The aim of analysing the data obtained from the survey was to describe dairy farmers according to their characteristic features. General linear model (GLM) was used to test the influence of location, herd category, health and farmer's status on milk yield/cow/day. The clustering results showed that high performing farms were those with small herd sizes (≤10 cows). Therefore, due to limited data obtained during the survey, the farms were divided into two groups according to herd size (≤10 and >10). According to location dairy farmers were also categorised into two urban and peri-urban areas. Chi-square statistic was used to test whether the proportion of dairy farmers using different roughages varied according to herd size category or farm location (urban versus peri-urban).

2.3 RESULTS

The results given are for the primary data collected by interview and the secondary data set obtained from ASMDFCA.

2.3.1 Secondary data analysis

Correlations

Correlations between pairs of the following variables were calculated: cows, calves, heifers, bulls, herd size, milk yield/farm/day and milk yield/cow/day. Correlation results are given in Table 2.2.

Table 2.2 Correlation between pairs of variables

	Cows	Calves	Heifers	Bulls	Herd size	Milk yield/farm/day	Milk yield/cow/day
Cows	1.000	0.60**	0.65**	0.45**	0.97**	0.85**	-0.10*
Calves		1.000	0.44**	0.34**	0.72**	0.58**	-0.09*
Heifers			1.000	0.43**	0.78**	0.64**	-0.004
Bulls				1.000	0.53**	0.43**	-0.08
Herd size					1.000	0.86**	-0.09*
Milk-yield/farm/day						1.000	-0.05
Milk-yield/cow/day							1.000

*p<0.05 **p<0.001

All variables were positively correlated (p<0.01) to each other but negatively correlated to milk yield/cow/day. As expected, cows, calves, heifers are all highly correlated with herd size, and cows and herd size are also highly correlated with milk yield/farm/day.

Cluster analysis

Cluster analysis revealed three groups of dairy farmers in and around Asmara. In Table 2.3, mean values are presented together with the RMSE (Root Mean Square of Error) and their respective significance levels for each cluster. Cluster 1, consisting of 41.6% of the dairy farmers, recorded medium mean numbers of cows and one bull. Cluster 2 consisting of 54.11% of dairy farmers, recorded the lowest mean numbers of cows and no bulls. Cluster 3, comprising 4.3% of the dairy farmers, had the highest mean numbers of cows and bulls and the highest milk output per farm per day, but with relatively low milk yield per cow per day. An hypothesis can be stated that in cluster 2 dairy farmers with small number of cows must produce least volume of milk/farm/day compared to cluster 3. Similarily for cluster 3 dairy farmers with the highest number of cows and bulls should have highest number of calves and heifers as compared to clusters 1 and 2.

Table 2.3 Cluster means and significance for a three-cluster solution

Variables	Cluster			RMSE²	Prob.
	1(n= 233)	2(n=303)	3(n=24)		
Cows[1]	10.00	5.00	23.00		
Bulls[1]	1.00	0.00	2.00		
Calves	3.00	1.00	4.30	2.10	<0.0001*
Heifers	3.00	1.00	7.00	2.30	<0.0001*
Milk yield/farm/day (kg)	49.70	24.30	117.50	37.20	<0.0001*
Milk yield/cow/day (kg)	5.00	10.5	5.70	29.48	0.0998
Bull/cow	13.90	0.00	14.30	5.71	<0.0001*
Calves/100 cows	34.00	37.80	22.40	31.59	0.0489**

1: cow and bull numbers are variables used for clustering 2: root mean square of error *p<0.001 **p<0.05

A higher proportion of dairy farms (54%) are located in peri-urban areas (Table 2.4). Farms in urban and peri-urban areas differ in terms of numbers of cows and bulls (p<0.001), numbers of heifers, milk yield/farm/day and calves/100 cows (p<0.05) (Table 2.5). Peri-urban farms had higher milk yield/cow/day and can be said to be more efficient. In terms of location the highest, intermediate and low proportion of dairy farmers of cluster 1, 2 and 3 belonged respectively, to the urban areas whereas medium, high and low proportion of dairy farmers of cluster 1, 2 and 3, respectively, belong to the peri-urban areas (Table 2.4). The highest proportion of peri-urban dairies belonged to cluster 2. The chi-square statistics revealed that there existed a significant relationship (p<0.001) between clusters and location with respect to the distribution of farmers.

Table 2.4 Partition of urban and peri-urban dairy farmers among clusters

Location	Cluster			Total
	1(n=233)	2(n=303)	3(n=24)	
1 Urban (n=253)	47.04% (n=119)	45.06%(n=114)	7.91%(n=20)	100%
2 Peri-urban (n=307)	37.13%(n=114)	61.56%(n=189)	1.30%(n=4)	100%

Table 2.5 Summary of mean values of variables, root mean squares and their respective probabilities in urban and peri-urban areas

Variables	Location: Urban (n=253)	Location: Peri-urban (n=307)	Root mean square	Prob.
Cows	9.30	6.30	7.30	<0.0001**
Bulls	0.62	0.39	0.56	<0.0001**
Calves	2.30	2.18	2.26	0.27
Heifers	3.00	2.30	2.59	0.0024*
Milk-yield/farm/day (kg)	44.90	33.80	42.20	0.002*
Milk-yield/cow/day (kg)	6.33	9.50	29.53	0.2070
Bull/cow	7.00	5.90	9.01	0.1423
Calves/100 cows	30.00	40.00	31.34	0.0002*

*p<0.05 **p<0.001

In order to check the validity of the proposed cluster, total canonical structures and their group means arising from discriminant analysis were used. According to Hair *et al.* (1992) variables with magnitudes of weights/loadings of greater than 0.3 are considered significant discriminants. Function 1 of the discriminant analysis revealed that bull/cow, calves, heifers, and milk yield per farm per day were the variables that make clear distinction between clusters (Table 2.6). Group means suggest that this function differentiates between cluster 2 and cluster 3. Thus, mean values of heifers, farm milk yield/day, calves and bull/cow were higher in cluster 3 than cluster 2.

For Function 2, heifers and milk yield/day had significant discriminant power. Group means suggest that it differentiated between cluster 1 and cluster 3. Indeed, Table 2.3 shows that the mean value of heifers and mean total farm milk yield/day in cluster 3 were higher than in cluster 1 (p<0.001).

Table 2.6 Total canonical structures and group means

Variable	Function1	Function2
Bull/cow	0.853333*	-0.395660
Calves	0.412506*	0.158993
Calves/100 cows	-0.095984	-0.182137
Heifers	0.482079*	0.635604*
Milk yield/day	0.468212*	0.749540*
Milk yield/cow/day	-0.053097	0.134641
Group means (centroids) following discriminant analysis		
Cluster1	1.96	-0.23
Cluster2	-1.83	0.06
Cluster3	3.74	1.48

* Important separators (discriminants) among clusters

2.3.2 Survey results

Primary data

Based on location, the 30 dairy farmers were categorised into urban and peri-urban. The entire herd of the surveyed population had 224, 127, 89 and 22 cows, heifers, calves and bulls, respectively. The average herd size was 15±11animals and the range in lactation length was 6-7 months. Out of a total of 30 respondents, 43.3% owned ≤10 and 56.7% owned >10 cattle. Holstein X Barka cross was the only breed used in the study area.

The common feed types used were green forage, vegetable waste, straw, hay, industrial by-products and compound feed (Table 2.7). Green forage supply consisted mainly of green maize and/or barley at milk stage, spinach and other leafy vegetable wastes, and limited quantities of lucerne and Napier grass. Green forage could be obtained either from irrigated land or purchased and as a result its usage varied between localities (Table 2.8). Farmers who cultivated vegetables for human consumption also sold vegetable waste to dairy farmers. In addition vegetable waste was also purchased from the local market at a negotiable price. Industrial by-products are obtained from the flourmill factory at Asmara. In feeding to animals all available feeds were chopped, and/or mixed (soaked) with water (personal observation).

Table 2.7 Common feed types used by 30 dairy farmers in and around Asmara

Feed type	No. of farmers	% of farmers
Cultivated forage	12	40.00
Purchased forage	11	36.70
Vegetable waste	27	90.00
Grazing	1	3.30
Straw/hay	30	100.00
Industrial by-product	30	100.00
Compound Feed[1]	30	100.00

1: Commercial feed

Table 2.8 showed that 52.9% of dairy farmers with herd size >10 cattle used cultivated forage as compared to 23.1% of farmers with herd size ≤10 cattle. A majority of peri-urban farmers and a few urban farmers used cultivated forage. On the other hand a majority of urban farmers and a few peri-urban farmers used purchased forage. Both urban (93.33%) and peri-urban (86.67%) farmers had almost equal access to vegetable waste. Based on chi-square statistics, it would appear that usage of cultivated and purchased forage was related to dairy farm location ($p<0.05$) since access to cultivated forage depends on access to land for cultivation. A higher proportion (23%) of peri-urban farmers have access to land for forage cultivation as compared with 13.3% of urban dairy farmers.

Table 2.8 Proportion of farmers within a herd category or within a location that use different roughages

Feed	Herd category ≤10	Herd category >10	χ^2	Prob.	Location Urban	Location Peri-urban	χ^2	Prob.
Cultivated Forage	23.1%	52.90%	2.7376	0.0980	20%	60%	5.00	0.0253*
Purchased Forage	38.5%	35.30%	0.0318	0.8584	66.67%	6.67%	11.60	0.0007*
Vegetable waste	100%	82.35%	2.549	0.1104	93.33%	86.67%	0.3704	0.5428

*$p < 0.05$

All farmers used one type of closed-tie indoor housing system (Annex iii). Approximately 73% and 27% of farms kept animals in own and rented barns, respectively. Of the urban farmers, 53% owned the barns and 47% rented, while the peri-urban group, 93% owned barns and only 7% rented.

Methods of breeding were assessed during the interviews. Out of a total of 30 farmers interviewed, 86.7% used natural mating, 3.3% used AI and 10% used both methods. Of those who used natural mating, 57% used their own bull(s) and 43% hired bulls. Mating was conducted using Holstein-Friesian bulls and AI using imported Friesian semen.

About 60% and 40% of farmers had full access and partial access to veterinary services, respectively. Economically important dairy diseases occurring or known to dairy farmers in both urban and peri-urban dairy farms were foot and mouth disease (FMD), lumpy skin disease, nutritional disorders, mastitis, abortion, tuberculosis, pneumonia, and digital problems. Since 1995, three outbreaks of FMD and about 321, 64, 560 and 200 cases of tuberculosis, brucellosis, mastitis and milk fever, respectively, were reported (MoA, 1997).

Dairying was considered by a majority (73%) of farmers as a primary means of income but by a few (27%) as a part time means of obtaining additional income. All farmers interviewed supply milk to the market. Of the total, 67% and 33% of the dairy farmers used formal and informal milk marketing outlets, respectively. Formal milk marketing is the supply of milk to the Asmara Dairy Plant (ADP) while informal milk marketing is direct supply of milk to consumers in the area. Milk is sold at a fixed price to the ADP but at a higher price in the direct (informal) market. Farmers sold milk informally or direct to consumers in order to compensate for or balance the loss incurred by selling to the ADP at a low and fixed price (personal observation). Milk yield/cow/day was influenced by location but not by herd size, access to health service, or farmers' status (Table2.9).

Table 2.9 The influence of location, herd size, health and farmers' status on milk yield

Variable	Level	Milk yield/cow/day (kg)
Location	Urban (n=15)	6.43**
	Peri-urban (n=15)	7.63**
Herd category	≤10(n=13)	6.98
	>10(n=17)	7.09
Health	Partial access[1] (n=12)	6.86
	Full access[2] (n=18)	7.21
Farmers' status[3]	Full time (n=22)	6.53
	Part time (n=8)	7.54

** Significant difference Error mean square = 5.337

1: Where farmers get partial veterinary service.

2: Where farmers get full veterinary service.

3: Category of farmers

Constraint analysis

Constraints to dairy production were determined using both informal (individual) and group-based discussions. Feed shortage, farmers advisory service, land shortage, disease, inconsistent AI service, labour, breed, feed cost, low milk price, milk handling facility and water shortage were constraints identified through individual discussion. Similar results were obtained with group-based discussions. The constraints were ranked according to their order of importance (Table 2.10). Shortage of land, lack of co-ordination and feed shortage were identified as the major constraints in and around Asmara. Constraint analysis revealed that all dairy farmers around Asmara faced similar problems, which have policy and technical implications.

Table 2.10 Ranking of farmer-identified dairy constraints

Constraint	Score	Rank
Shortage of land	8*	1
Lack of co-ordination	7*	2
Feed shortage	7*	2
Lack of skilled manpower	5	3
Disease and shortage of vet. drugs	3	4
Lack of know-how	3	4
Inconsistent A.I. service	3	4
Lack of extension package	2	5
Lack of milk cooling and transport facilities	0	6

*Major constraints

The feeding systems used by farmers showed that there is shortage of feed resources. Basal and supplementary rations were not separated when feeding dairy cattle. All available roughages and concentrates were mixed together and offered to the animals (personal observation).

Dairy housing used by the farmers was of poor design and location. Most urban dairies were concentrated in the residential areas. In most cases insufficient land space was available for separate calf pens, milking parlour, feed store and dung pit and other related services. The barns were poorly ventilated and poorly lit. Due to improper manure disposal, the animals were not clean. The accumulated manure also produced a bad smell that could be a concern in the residential areas (personal observation).

2.4 DISCUSSION

Characterisation of dairy farmers

The results of this study revealed that distinct groups of urban and peri-urban dairy farmers exist in and around Asmara. Urban dairy farms are those that are located inside Asmara city. Dairy farms located outside Asmara city are characterised as peri-urban dairies. Staal and Shapiro (1996) characterised urban and peri-urban dairies as systems that involve the production, processing and marketing of milk and milk products that are channelled to consumers in urban centres in the tropics and sub-tropics.

The relationship between pairs of variables showed that milk yield/farm/day was highly dependent on herd size. In other words if an increased farm milk yield/day is required then there should be an increase in herd size. With the existing shortage of land and feed resources this might not be a viable strategy unless farms are relocated out of the urban centres. Another alternative would be to aim for an herd size at which individual cow efficiency is high.

Clustering of dairy farms illustrated the existence of different groups. The observed variation in milk yield/cow/day among the three clusters might be due to differences in herd size and number of bulls. Farms with large herd size might face higher competition for feed among the herds because feed is allocated according to the milk supplied to Asmara Dairy Plant (ADP). The higher the number of lactating cows in the herd the more milk will be supplied and more feed allocated and vice versa. On the other hand small herd size farms might take better care of their animals. Small herd size farms do not keep breeding bulls but might depend entirely on AI, thus reducing the risk of transmitting reproductive diseases and (or) producing genetically inferior replacement heifers. In addition a reduced cost of bull management could spare additional feed for feeding cows. The majority of farmers with small herd size belong to the peri-urban area (Table 2.4) and have access to cultivated forage (Table 2.8) that could improve the nutritional status and milk production per animal.

Feed resources most commonly used by dairy farmers in the two localities are quite similar. Availability and variety of feed dictates the feeding systems on the dairy farms. As a result, indoor feeding where animals are kept tied in houses and are dependent on a mixed ration, is practiced (personal observation). The way farmers feed and manage their cattle could indicate the existence of problems related to feed and feeding. The most common system is a zero-grazing one where dairy cattle are housed in tie stalls. They are often group fed from the manger with the same composition of feed regardless of age and stage of lactation. The farmers depend mostly on purchased feed resources. Tegegne *et al.* (2000) reported similar results on dairy farms in Addis Ababa, Ethiopia, where there is little or no grazing within the city and stall-feeding is based on purchased hay and concentrate. Green forages in the study area were obtained from the riverside irrigation by the continuous flow of the "*Mai-bela*" sewage line that comes out of Asmara City. The available grass hay is of extremely poor quality. Standing hay is harvested at a very lignified stage when its nutritional value is extremely low (personal observation). Traditional subsistence farmers supply dairy farms with barley and wheat straw but it fluctuates with available rainfall. At times of scarcity the price of straw rises whereas the milk price is fixed, consequently affecting farmers' income and profit. Although feeding has shifted from a land resource based (grazing land) to a concentrate or by-product based system, farmers raise the problem of unequal distribution and general scarcity. The only source of industrial by-products in the study area is Red Sea Flourmill factory at Asmara. Private feedlots, Elabered commercial dairy farm, poultry farmers and private livestock feed plants compete heavily for the supply of wheat bran and wheat shorts. To control the sale of unpasteurised milk to consumers MoA introduced a feed distribution system where dairy farmers are able to obtain feed upon certification of milk supplied to the Asmara Dairy Plant (ADP). However, dairy farmers are not satisfied with the system because milk supplied to ADP fetches lower price, compared with the direct sale of milk to consumers. For this reason they are discouraged from following a formal milk market.

Due to inconsistent AI service a majority of farmers might be obliged to use own or rented bulls. This could lead to a high cost of bull keeping that lowers the income of dairy farmers. Breed improvement cannot be attained as required because of untested breeding bulls. Sharing of bulls or bull exchange could also result in the transmission of reproductive diseases. Bull testing, keeping breeding records and control of reproductive diseases could help to attain required breed improvement.

Dairy farmers in the study area were categorised as being market-oriented. A majority of the milk produced was supplied to consumers in the urban areas through formal and informal marketing channels. Similar results were reported in Ethiopia, Ghana and Mali (Tegegne *et al.*, 2000; Smith and Olaloku, 1998). However, unlike the results of this study about 60% of milk marketed by smallholders in Kenya was found to be sold to consumers through the informal market (Staal and Shapiro, 1994).

The role played by dairying as a primary means of obtaining income and as a part-time means of obtaining additional income is similar to reports from Ethiopia and Zimbabwe (Tegegne *et al.*, 2000; Smith and Olaloku, 1998, Hanyani-Mlambo *et al.*, 1998) where cash income from sale of milk and/or breeding animals and utilisation of available resources (land, feed, labour, capital) are the most important reasons for keeping dairy animals in urban and peri-urban dairy production systems.

Constraints to dairy production

The identified constraints (Table 2.10) could be grouped into policy, technical and institutional issues. Land is the only policy-related constraint whereas feed, disease and AI are technical constraints. Lack of coordination, lack of skilled manpower, lack of know-how and lack of extension packages are institutional constraints. Even though interrelated constraints are identified the major ones are land, feed and lack of co-ordination. In contrast with this study, in South Africa, animal theft was among the top agricultural constraints identified by farmers (Letty *et al.*, 1999; Letty *et al.*, 2000).

Land shortage is reported to be a serious problem affecting housing and forage cultivation (Zeggu, 1997; MoA, 1999; Teclu, 2001). The suspected root causes of land shortage were land policy and land tenure system. The land proclamation policy in Eritrea declared that land belongs to government and is freely accessible to every citizen (Tronvoll, 1998) but it has not been implemented yet. Lack of land is suspected to be responsible for the shift of dairy systems from land resource based (grazing) to concentrate (by-product) based. Survey results also revealed that all dairy farmers feed their cattle on concentrates (industrial by-products). Similar results have been reported in the Addis Ababa milk shed, Ethiopia (Staal and Shapiro, 1996). The issue of land ownership with respect to dairy production is particularly important in the urban and peri-urban areas. In addition to the land policy, the traditional land tenure system also does not encourage dairy farmers to establish perennial forages and build dairy barns on the allocated land. According to custom, communal (*Diesa*) farmland in parts of Eritrean highlands is re-distributed every 5-7 years and as a result farmers are not motivated to establish permanent possessions (Tronvoll, 1998). Farmers have users' rights, not owners' rights over the land they till. The new legislation allows a lifetime lease on land and a new legal right in land to be distributed to all Eritrea citizens without discrimination (Tronvoll, 1998). Accordingly it has also been argued that land can be leased for investment purposes. Dairy farmers are, however, not interested in its bureaucratic complications because a majority are small to medium scale farmers who claim that the policy only satisfies the demands of large-scale investors (personal communication). The effect of land as a major constraint of dairy production is reflected in feeding and housing systems.

Dairy farmers have developed their own feeding strategies hoping to overcome feed shortages (personal observation). All available feeds such as forage (green and dry), wheat bran and other industrial by-products are mixed and the mixture is soaked in water for some hours or overnight and fed twice a day (Annex iii). Little attention is given by farmers to water their cattle according to their daily requirement because they assume that the feed-water mixture can fulfil daily water requirement (personal observation). Cases of acidosis and laminitis can be blamed on poor feed management. It is also common to see cows with rumen problems (Annex iii). The only mineral supplied with the feed is common salt (personal observation), thus cases of hypocalcaemia, hypo-magnesia and hypo-phosphotaemia are common (MoA, 2001). Farmers perceive that this system of soaking feed improves palatability. It is possible that this type of feeding system can precipitate nutritional and health related problems. Besides this the feeding system (mixing and soaking) could increase labour costs.

The impact of the land problem on housing was observed during the study. In both urban and peri-urban farms, dairy cattle were confined in houses not properly designed for dairy purposes. With the exception of a few old dairy buildings inherited from former Italian settlers the existing barns do not have the related service structures such as drainage, dung pits or milking parlours. Most urban dairies operate as back yard operations, utilizing whatever space is available in residential compounds. These dairies conflict with neighbourhood authorities in terms of waste disposal. Due to unhygienic conditions, zoonotic diseases such as tuberculosis and brucellosis can be transmitted to humans. Similar results were reported by Devendra (2001) in peri-urban areas of South-East Asian countries where efficient waste disposal systems were not in place and often non-existent, dairy wastes consequently presenting a major health hazard. The buildings are quite unsuitable for keeping dairy cattle comfortable and do not allow a favourable working environment. They are very old, with faulty design, and poorly maintained. The only component that is common to all is the cowshed where all classes of animals are kept under the same roof. In most farms no open yard for exercise is provided. Therefore, poorly designed houses with very low rooves, poor floor designs, poor drainage systems, poor ventilation, and, poor lighting and where dairy cattle are kept congested, were observed (Annex iii).

Economically important diseases reported during this study agree with the information obtained from MoA (2001). According to the MoA (2002) vaccinations against infectious diseases are given regularly but the most pronounced dairy diseases are those related to management and feeding. Diseases such as tuberculosis, digital problems, and lumpy skin disease could be the result of poor housing. In-door keeping of animals with improper ventilation could predispose cattle to tuberculosis.

Dairy development is the result of organised and coordinated activity of different actors. The organization of the system depends on the strength of communication among research, extension and farmer. According to the National Livestock Development Policy (NLDP, 1996) the role of government and farmers is clearly defined. However dairy farmers, as direct beneficiaries of the system, blamed the MoA for not playing her expected role of coordination, which was raised as one of the major dairy constraints. The MoA is characterised in the process as a non-participatory decision maker. Due to limited opportunity and authority, farmers do not participate in making decisions that affect them. For instance the relocation of dairy farms from inside the city to the surrounding areas has failed because the process was not participatory from the beginning. The government intervention is based on a top-down approach, which basically is the imposition of ideas on farmers. Generally it has been observed by this study that there exists a communication gap somewhere in the system.

The role of research in dairy development has been defined clearly (Annex ii) however little or no research has been conducted to understand urban and peri-urban dairy. As a result, limited relevant information has been disseminated. The research-farmer relationship can be bridged by education, general extension and consultation but no specialized dairy extension system exists. The only existing extension service is mainly on crop agriculture or general livestock production. Shortage of qualified personnel was cited as the cause of poor extension services (MoA, 2000). However, the core causes could be lack of a thorough understanding of production systems, lack of extension activities to transfer new technology and knowledge gained from researchers to farmers and vice versa, lack of awareness of the local experience and knowledge and absence of meetings for consultations and discussions with dairy farmers. In addition, poor education and managerial expertise of farmers also contributed to the ineffectiveness of extension services.

2.5 CONCLUSION

The results of the study revealed that there is a foundation for dairy development in Eritrea. This consists of dairy farmers with distinct characteristics. However, due to shortage of land, lack of co-ordination and feed shortage little or no progress has been achieved to-date. Therefore, to alleviate the existing problems of land, co-ordination and feed, a holistic approach of problem identification involving all stakeholders should be done on aspects such as planning, policy revision and formulation. Furthermore, research on dairy systems targeting urban and peri-urban farms should be conducted.

CHAPTER THREE

DAIRY HERD CONSTRAINT ANALYSIS

Abstract

The objective of the study was to identify constraints to dairy production in the Elabered dairy herd in Eritrea. Data on lactation number, breed, last calving date, AI date and due date, body weight and height, milk yield per cow, condition score, number of AI's per calf, pregnancy status of cows were analysed using "Gwion dairy analysis programme by dairy man". Mean milk yield, condition score and average live body weight of the herd were 11.6±2kg/day, 2±0.56 and 497.63±89kg, respectively. Days in milk of first calvers and older cows fell between the ranges of 41-327 and 201-245 days, respectively. First and second calvers were below target average mature body weights. Mean number of lactations was 3.3±1.8 and age at first calving of the herd ranged between 39 and 43 months. Mean calving interval (CI), calving interval spread index, voluntary waiting period, average services per pregnant cows (SPC) and maximum services per conception were 435±88 days, 55, 52 days, 1.8±1.1 and 7, respectively. The average daily gain/day of age (ADA) of heifers was between the range of 0.300 and 0.399 kg/day whereas the target is 0.614 kg/day. It was observed that a majority (96%) of heifers had daily gains that were below the target. Heifers did not achieve their target performance at all stages. Body weight, average daily gain (ADG), weight at conception and ADA were all low. Low body weight gain at all ages indicated that heifer growth was poor, heifers are served at a very light weight and are calving down too small. Poor heifer growth and poor fertility status were major technical constraints identified. The suspected causes were discussed and further diagnosis and analysis of the overall situation of the herd is recommended.

Key words: average daily gain, calving interval index, dairy constraint, heifer growth, mean milk yield, mean calving interval.

3.1 INTRODUCTION

Agriculture is the mainstay of the economy in most Sub-Saharan African countries. Livestock also contributes a substantial amount to the economy of these countries to improve the livelihood of the subsistent farmers on the one hand and increase the cash flow of commercial farmers on the other. Livestock supports a majority of the farming community in subsistence agricultural systems. As a major component of agricultural systems in the tropics, ruminant livestock serve as a source of direct cash income, a capital asset, support for crop farming by producing manure for fertiliser, and as a source of power for transport and cultivation, rather than providing food. Nevertheless one function, the production of milk for human food, is often the primary reason for keeping livestock. 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. Urban and peri-urban dairy farmers keep dairy cattle to meet their subsistence needs and as a source of income from milk sales. Walshe *et al.* (1991) pointed out that where market conditions are suitable, dairying is preferred to meat production since it makes more efficient use of feed resources and provides a regular income to the farmer. It is also much more labour-intensive and supports substantial employment in production, processing and marketing. Apart from the traditional or subsistent systems, commercial dairy systems require improved management. The introduction of improved dairy breeds, nutrition, proper health care, and a good marketing infrastructure are among the requirements for dairy development.

Milk production depends entirely on both technical and biological factors. These factors impinge on the production of individual animals as well as of the whole herd. In addition to the biological factors, dairy cow productivity could be affected by managerial skills and systems. The success of any dairy production system depends on the managerial aspect of the dairy farmer, both for production and reproduction parameters. In addition it also depends on adequate production and herd fertility or reproduction. Poor herd fertility could affect the sustainability of a dairy system. Herd health and reproductive management, feeds and feeding management, breeds and breeding systems are some of the technical and biological factors affecting the fertility status of a cow. The production ability of a dairy herd depends on the fertility status of individual animals, which in turn affects the performance of the whole herd.

Investigating the productive and reproductive performance status of a dairy herd could help to identify constraints that hinder productivity.

In common with other Sub-Saharan African countries, livestock are important resources in Eritrea, representing a substantial proportion of household incomes and protein intake. They also make a significant contribution to the national economy through the provision of raw materials for the processing industry such as milk, meat, hides and skins and the creation of employment. Among the major constraints to livestock production in Eritrea are feed shortages, animal diseases, a lack of proper data for planning purposes and a lack of strong livestock support services (MoA, 1997).

Basically two distinct dairy production systems exist in Eritrea, the traditional one on which a majority of the farming population depends for milk and, commercial systems which supply the urban population. Dairy production in Eritrea has a long history, beginning with the introduction of modern agriculture by Italian settlers during the end of the 19th century. Since its introduction it has played a significant role in supplying milk and milk products to a majority of urban population. The dairy sector had good potential for development but declined with intensification of the war of independence and repeated droughts. Immediately after independence (in 1991), attempts were made to revive and re-habilitate this sub-sector. Even though there were good grounds for revival and rehabilitation the expected progress was not achieved because of different constraints. The constraints are not yet fully identified or properly analysed. The objective of this study was to identify major problems that constrain the dairy sub-sector of the agricultural economy of Eritrea with special emphasis on Elabered dairy farm.

3.2 MATERIALS AND METHODS

3.2.1 Location of the study

The study was conducted at Elabered dairy farm, Eritrea. Elabered dairy farm is located in the Anseba administrative zone about 60 km north of the capital Asmara. The area is found in the central highland zone of the country at an altitude of about 1800 metres above sea level. Its establishment was related to the introduction of modern dairy farming in the country. It was among the few dairy farms that supplied a large amount of milk marketed to a majority of the urban population. Until the mid 1970's, it operated well but the nationalization policy of the former military government of Ethiopia caused a decline to levels below its potential. After independence the dairy farm was revived with the remaining few pure Holstein-Friesian and grade animals (crosses) and the importation of in-calf heifers from the Netherlands. This dairy farm is among the major suppliers of milk to the urban population in the capital Asmara and Keren town. It is the only one that keeps records.

Currently, the farm consists of about 700 dairy cattle among which 400 are cows and about 300 followers. The farm owns about 56.5 ha of land for forage cultivation where about 52 ha of lucerne and about 4.5 ha of elephant grass (Napier) are currently under cultivation. The types of feeds used are industrial by-products (concentrates) and cultivated forage and hay (Table 3.1). The forages most commonly used are lucerne, elephant grass, corn fodder (limited) and standing hay. Concentrates used as supplements are wheat bran, wheat shorts, brewers' grain, oilseed cake, and dairy ration or compounded feed (when available).

Generally, group feeding is practised on the farm and animals are fed in groups with their age mates. The amount offered depends on the availability of ingredients. Calves are offered an average of 3 – 4kg of milk per day and weaned at 90 days of age. Before weaning they receive a small amount of concentrate. After weaning they are offered grass hay and alfalfa. A year round breeding system is practiced in the farm i.e. animals are mated when they are spotted in heat.

Table 3.1 Feed allocation at the farm

Class of animal	Feed type	
	Concentrate (kg/day)	Roughage (kg/day)
1. Milk cows	3-8	15-25
2. Dry cows[1]	3	10-15
3. In-calf heifers	3	10
4. Breeding & young heifers[2]	2	-

1:Additional 4kg concentrate /cow/day is offered during the last two weeks of pregnancy for steaming up pregnant cows.

2:Breeding and young heifers are kept grazing on standing hay in the farm and little or no green forage is offered.

3.2.2 Data collection

A total of 511 animals with usable records, comprising 344 cows and 177 heifers were used. Data were collected for individual cows comprising lactation number, breed, last calving date, AI date, expected calving date, body weight, height, milk yield per cow per day, condition score, number of AIs since last calving date, pregnancy status of the cow and 300 day milk record/cow. In the case of heifers, date of birth, service date, body weight, height and condition score were collected. A weigh band (tape that correlates weight with heart girth) was used to measure heart girth for weight. Heart girth and height at withers were measured for each animal. All animals were condition scored using the technique developed at the British National Institute of Research in Dairying (NIRD) (Van der Merwe and Stewart, 1995). By this technique the animal was given a condition score on a scale that goes from 0 (very poor) and 5 (grossly fat)(Annex iv). Condition of a cow was assessed by feeling with hand the loin area covering the horizontal projections of the lumbar vertebrae, and around the tailhead. Milk production data were obtained from records on the farm.

3.2.3 Data analysis

In order to calculate days in milk, it was necessary to standardise different data collection dates to one starting date. Date adjustments were made in Excel 2000. This was then saved in a comma separated value (CSV) format suitable for analysis using an MS-DOS based programme for dairy herd analysis (Jones and Stewart, 1999). This programme for herd analysis discarded all animals with incomplete or obviously incorrect data especially for dates of calving and insemination.

Data were analysed using "Gwion Dairy Analysis Program by the Dairyman" (Jones and Stewart, 1999). This programme sets targets for various herd parameters based on expected values for dairy herds. Where appropriate, these targets are derived for the herd being analysed. For example, target average daily gain (ADG's) for heifers are based on the mature weights reported for the cows. This program uses the following formulae to estimate fertility status such as mean calving interval, distribution of intercalving periods (ICPs) and intercalving period (ICP) in days. Further details of these analyses can be found in Jones and Stewart (1992).

The intercalving period (ICP) was calculated thus:

Mean ICP = exp $\{(\ln BP_1 + \ldots + \ln BP_n)/n\}$ +280+VWP

Mean breeding period (BP) = exp $((\ln BP_1 + \ldots + \ln BP_n)/n)$

Where: BP = breeding period = ICP-VWP-280

n = number of cows

VWP = voluntary waiting period

Services per conception (SPC) was calculated using the formula

SPC = Total number of inseminations to pregnant cows/ No. of pregnant cows

Cumulative yields for the first 56, 84 and 300 days in milk of cows at various stages of lactations were compared against the calculated 125% and 75% of the 56, 84 and 300 days milk yields. Days in milk, mean milk yield/cow/day and 125% and 75% of mean milk yield were calculated as follows:

Days in milk (DIM) = date of recording - last calving date

Mean days in milk= $\sum$DIM/n

Where: n = number of cows

125% of X day milk yield = cumulative yield from calving up to day X*125%

75% of X day milk yield = cumulative yield from calving up to day X*75%

Where: X= 56 or 84 or 300 days

This analysis is important to select or reject cows based on their milk yield potential for rebreeding. Accordingly, cows giving > 125% of mean will be considered as superior and those giving <75% of mean as inferior.

Some of the targets need user decision. For instance, target body weight was set based on mature cow weight of the herd because it could reflect the herds' performance and management (Stewart, personal Communication). Target daily gains were set depending on the age when animals are required to calve for first time i.e. the biological target. However, age at first calving (AFC) should not normally be less than two years of age or greater than three and heifers should have achieved about 90% of their average mature mass when weighed just before calving (Stewart, 1995). It has been shown that normal age at first calving (AFC) in large breeds is 27-30 months, but it is also possible for heifers to calve as early as 16 months (Gardner *et al.*, 1977; Sejrsen *et al.*, 1982; Heinrichs and Hargrove, 1987). Provided that environmental and nutritional factors are favourable, heifers could breed at 15 months and calve at 24 months of age (O' Connor, 1992). The breed in this study was Holstein-Friesian and Holstein grade animals (crosses). For comparative purposes, target weights and ADG for various AFC were based on large breed standards. Provided management and other environmental factors are favourable, AFC could be decided upon by the user (farmer) i.e. at what age heifers are required to calve for the first time.

3.3 RESULTS

3.3.1 Average status of cows

Mean daily milk yield, condition score, average live body weight and days in milk were 11.6±2.08 kg/day, 2±0.56, 497±89kg, 214.67±132.9days, respectively. The mean daily milk yield was lower than the expected target. A majority of cows yielded below the target mean milk yield (Fig 3.1).

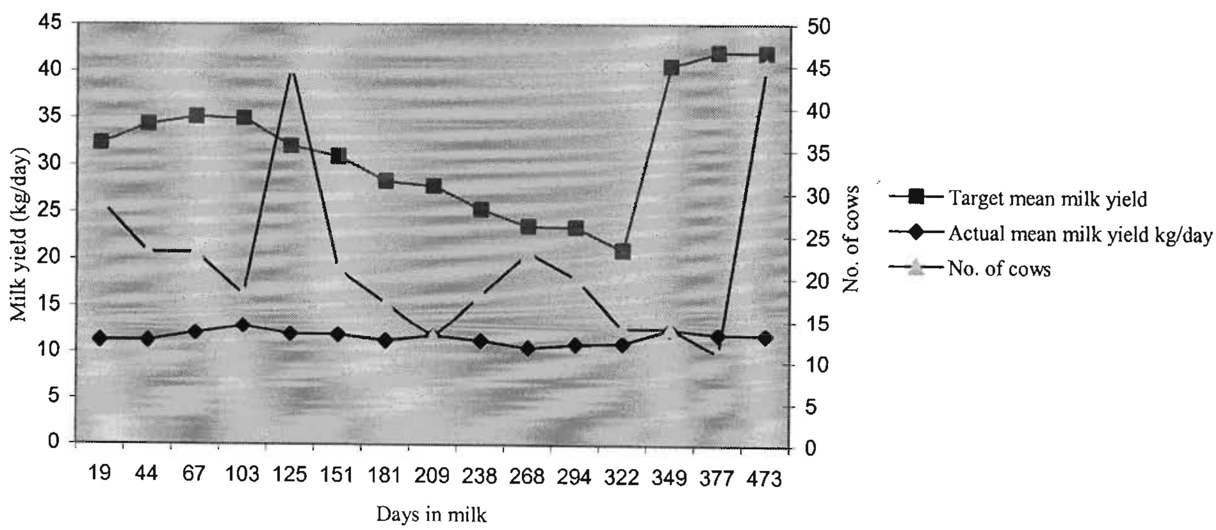

Figure 3.1 Daily milk yield versus Target milk yield of cows

Disparity was observed between the mean and the target milk yield (kg/day) of the herd. This could illustrate that there exists constraining factors that hinder the herd from performing to its potential. The efficiency ratio (kg 4% fat corrected milk produced in 300 days per kg average cow weight) of the herd was 6.7. Mean body weight of cows with more than one lactation was calculated. The average status of cows by stage of lactation showed that a majority of cows were below the target points. The average body weights of mature cows, 2nd and 1st calvers were 530±78kg, 479±68kg, 417±74kg, respectively, whereas the desired target weights were 528, 515 and 502kg, respectively. It can be noted that mature cows were close to their target weights while 2nd and 1st calvers were well below their target weights. As noted earlier, target weights are estimated from the observed mature cow weights. This is a deliberate algorithm in the program to ensure that targets are based on the genetic composition of the actual herd and not on some arbitrary breed standard. In practice this means that in stunted herds, target weights are based on the expected ADGs of heifers and weights of first and second calvers will not stabilise (become constant) until the mature cow weights stabilises (Stewart pers. comm.). A key problem is poor heifer growth rate, consequently, mean heifer weights were found to be far below the target weights (Table 3.2).

Table 3.2 Mean body weight, height, condition score, mean milk yield, and life expectancy of cows.

Age group Cows	No. of animals	Weight (kg)	Height (cm)	Condition score	Mean milk yield (kg)	Life expectancy (lactations)
Mature	206	530±78(528)[2]	139±7(139)[2]	2.0±0.6(1.8)[2]	12.23±1.8	4.41
2nd calvers	55	479±68(515)[2]	137±7.3(139)[2]	2.0±0.5(1.8)[2]	10.3±1.5	3.90
1st calvers[1]	73	417±74(502)[2]	135.6±7.34(136)[2]	1.9±0.5(1.8)[2]	10.89±2.37	3.27
Heifers						
>24months	100	294.7±86(439)[2]	122±9(141)[2]	1.6±0.34(2.5)[2]	-	-
15-24 months	75	180±30(274)[2]	106.7±4.9(128)[2]	1.23±0.3(2.5)[2]	-	-

1: First calvers were about 84kg = 17% underweight.
2: Target values are given in parenthesis.

3.3.2 Herd profile

Age

A profile of cow age, given by lactation number (Fig 3.2), illustrated that a majority of cows in the herd were at their 1st (22%) and 4th (21%) lactations whereas very few (2%) cows were in their 8th lactation with a mean of 3.3±1.8 lactations. Approximately 76% of cows fell into the range of 1 to 4 lactations.

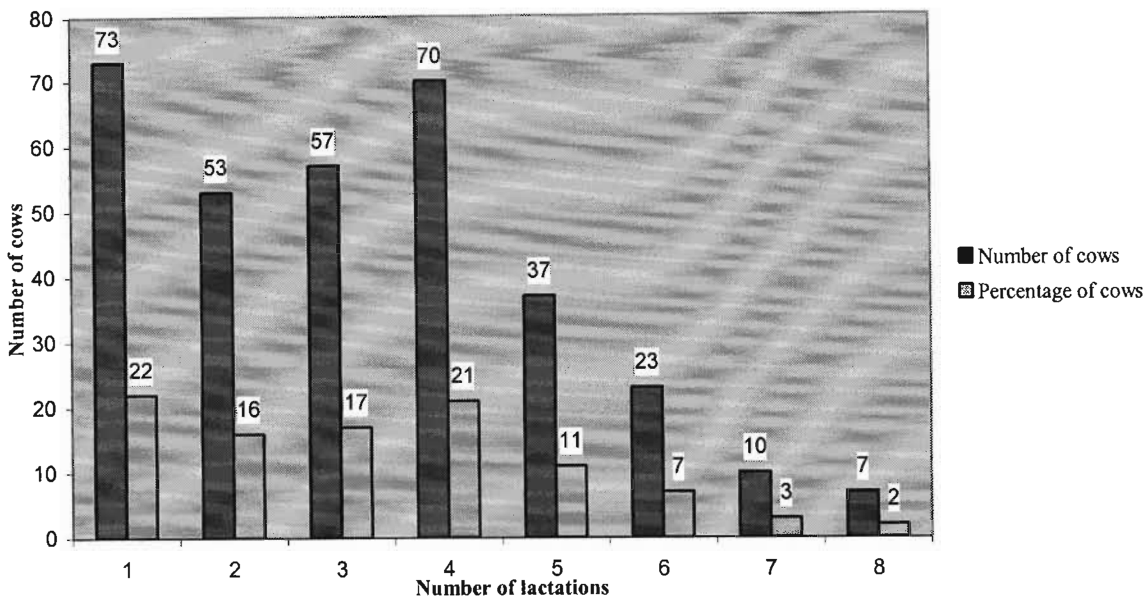

Figure 3.2 Profile of cow age by number of lactations

Condition Score

Profile of condition scores in the herd showed that 10% (33), 22% (72) 36% (120), 23% (77), 9% (30) and 1% (3) of the cows had body condition scores of 1,1.5, 2, 2.5, 3 and 3.5, respectively. The analysis showed that a majority (36%) of cows had a mean condition score of 2±0.6.

Heifer Productivity

The average daily gain/day of age (ADA) of heifers was within the range of 0.300 and 0.399 kg/day whereas the target is 0.614 kg/day. It was observed that a majority (96%) of heifers had daily gains that were below the target. The poor ADA of heifers was the result of the poor heifer growth.

Age at first calving in the herd was within the range of 39 to 43 months. Out of 35 heifers confirmed in calf, a majority (66%) calved at a very advanced age. The predicted weight at first calving was 72% of the predicted mature cow weight whereas the target is > 100% of mean mature weight. The mean weight of 1st calvers showed that a majority calved at a body weight within the range of 400-499 kg (Fig 3.3).

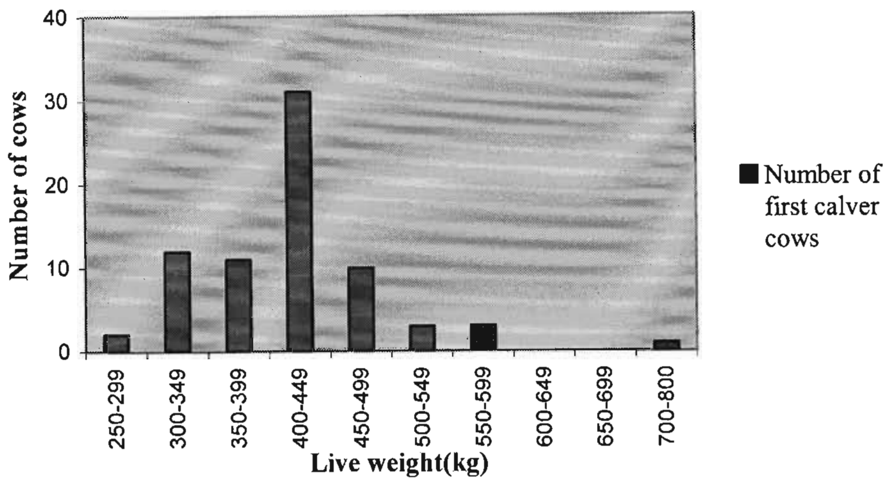

Figure 3.3 Profile of 1st calver cow weights (kg)

Milk production

A milk profile analysis of first calvers showed that yields were far lower than the genetic potential of the cows. Mean milk yields of first calvers (n=73) and older cows (n=261) were 10.9±2.4 and 11.8±2 kg/cow/day, respectively (Table 3.3). Days in milk of first calvers and older cows fell between the ranges of 41-327 and 201-245 days, respectively.

Table 3.3 Profile of cows in milk, milk yield (kg/day) and percentage of cows

Cows in milk	kg/day	% of cows
1st calvers (n=73)	0-4.97	12
	5-9.97	23
	10-14.9	62
	15-25	3
Older cows (n=261)	5-9.97	9
	10-14.9	83
	15-25	8

Intercalving Interval

Mean calving interval of cows (CI), intercalving period, calving interval index, average services per pregnant cow and heifer were calculated from the herd data. Intercalving period data are summarised in Tables 3.4 and 3.5.

Table 3.4 Intercalving period (ICP) distribution summary

ICP (days)	No of cows	Actual %	Target%*
<330	0	0	0
330-400	81	48	90
>400	88	52	<10

* Stewart (1995)

Table 3.5 Calving interval spread index*

CI (days)	No of cows	% of cows	Target	Difference
<344	13	7.70	2	5.70
344-364	24	14.20	50	35.80
365-385	31	18.30	25	6.70
386-406	16	9.50	12	2.50
407-427	12	7.10	6	1.10
428-448	12	7.10	3	4.10
>448	61	36.10	2	34.10
Total	169			90.00
			Index	55.00

* This is a measure of the spread of CI's.

Targets are based on realistic modelling of the results that could be expected in fertile well-managed herds. A herd with a perfect spread of CI's would have an index of 100.

CI index = 100-(sum of differences)/2,

Where: sum of differences = $\sum$(target - % cows)

Mean calving interval, calving interval spread index, average services per pregnant cows (SPC), and maximum services per conception for 169 cows confirmed pregnant in the herd were 435±88days, 55, 1.8±1.1, and 7, respectively. Calving interval spread index of 55 means that there is a wide spread of calving intervals about the mean.

3.3.3 Cumulative milk yield

Comparing milk yields for the first 56, 84 and 300 days of production cows at various stages of lactation were giving <125% but >75% of 56, 84 and 300-day mean milk yield. Thus cows in the herd are not considered as superior or inferior, but their genetic potential might not be expressed currently due to nutritional and other environmental factors (Table 3.6).

Table 3.6 Days in milk, number of cows and their milk yield at different stage of lactations

Days in milk	Variable	Lactation1	Lactation2	Lactation3	All ages
56	No. of cows	14	9	29	52
	Production 1st 56 days	396	535	687	583
	Mean kg/cow/day	7.1	9.6	12.3	10.4
	Mean days in milk	28	29	32	30
	125% of 56-days[1]	495[A]	669[A]	859[A]	728[A]
	Kg/cow/day[1]	8.8	11.9	15.3	13.0
	75% of 56-day mean[1]	297[B]	401[B]	516[B]	437[B]
	Kg/cow/day[1]	5.3	7.2	9.2	7.8
	Live mass	339	434	490	440
84	No. of cows	15	9	51	75
	Production 1st 84 days	638	803	1020	918
	Mean kg/cow/day	7.6	9.6	12.1	10.9
	Mean days in milk	30	29	47	41
	125% of 84-days[1]	798[A]	1003[A]	1275[A]	1147[A]
	Kg/cow/day[1]	9.5	11.9	15.2	13.7
	75% of 84-day mean[1]	479[B]	602[B]	765[B]	688[B]
	Kg/cow/day[1]	5.7	7.2	9.1	8.2
	Live mass	338	434	497	458
300	No. of cows	54	37	154	245
	Production1st 300 days	3117	2775	3346	3214
	Mean kg/cow/day	10.4	9.3	11.2	10.7
	Mean days in milk	139	171	133	140
	125%of 300-days[1]	3896[A]	3469[A]	4182[A]	4018[A]
	Kg/cow/day[1]	13.0	11.6	13.9	13.4
	75% of 300-day mean[1]	2338[B]	2081[B]	2509[B]	2411[B]
	Kg/cow/day[1]	7.8	6.9	8.4	8.0
	Live mass	394	475	513	481

1: Values calculated by the programme
A: calculated values <125% of 56 or, 84 or, 300-day mean milk
B: calculated values >75% of 56 or, 84or, 300-day mean milk yield

3.3.4 Growth of heifers

At most stages heifers did not achieve their target performance (Table 3.7). Body weight, average daily gain (ADG), weight at conception, ADA (average daily gain/day of age) were all low. Low body weight gain at all ages indicated that heifer growth was poor, heifers were served at a very light weight and were calving down too small.

Table 3.7 Summary of age at first calving, target weights for various ages at first calving and herd result

Age at 1st calving (months)	Target for various ages at 1st calving 24	30	36	42	Herd result 42
6 months to conception (141 heifers)					
Weight at 6 months (kg)	158	158	158	158	100
ADG 6 months to conception (kg/day) [2]	0.734	0.588	0.469	0.399	0.201
Weight at conception (kg)	354	423	454	483	264
Age at conception (months)	15	21	27	32.8	32.8
Conception to calving (35 heifers)					
ADG, AI to calving (kg/day)	0.623	0.519	0.453	0.397	0.543
Mean pre-calving weight (kg)	555	568	581	594	407
Interim target weight (kg)	481	487	494	501	
ADA, birth to calving (kg/day) [3]	0.608	0.493	0.417	0.363	0.243

2:ADG: average daily gain within particular time (days, weeks, months, etc.)
3:ADA: average daily gain per day of age.

The difference in ADG observed in the herd between AI to calving and 6 months to conception compared with the target may be due to feeding system because young heifers in the farm are kept only on grazing. Heifer body weights were regressed against age in months. Basically, heifers were gaining low body weight for every unit of age, i.e. about 8 kg/month. Figure 3.4 shows the actual and expected/target heifer body weights regressed against age.

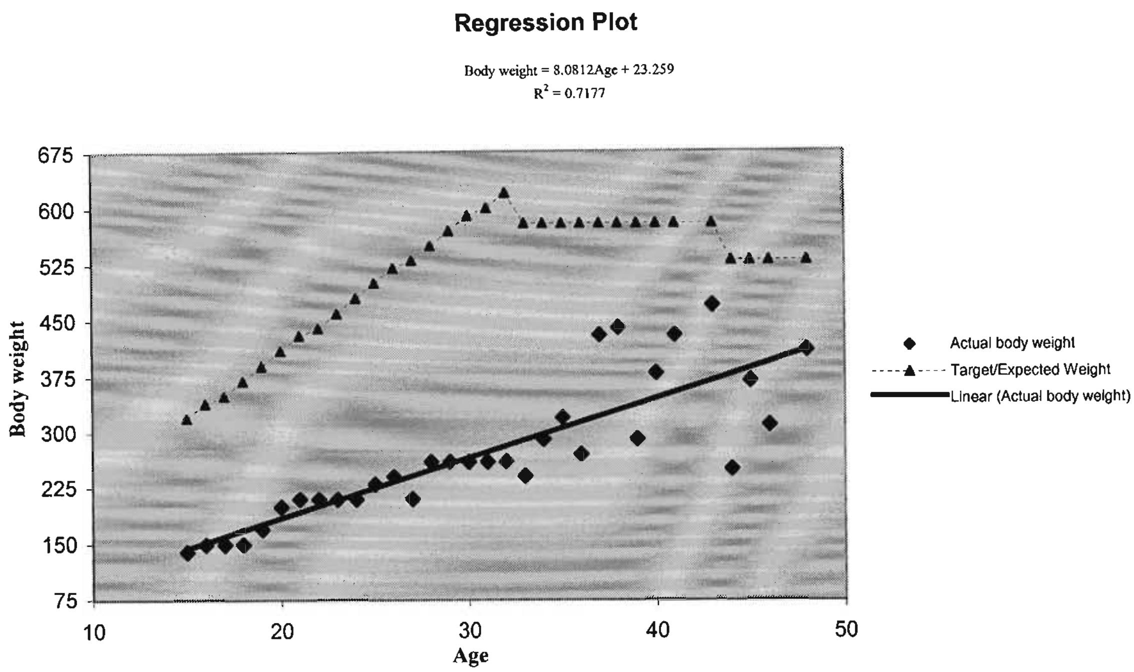

Figure 3.4 Age and weight relationship of heifers.

3. 4 DISCUSSION

Herd performance reflects management which encompasses different aspects, including feeding, health, reproductive management and other factors that determine the productivity and production of the herd. The level of dairy herd fertility or reproductive management determines sustainability of a dairy herd. Ideally a good dairy cow is one that is healthy, reaches economic production at an early age, calves each year, and yields the desired milk quantity and quality. A dairy cow may be said to be infertile when its reproductive performance falls below the average for the breed in a particular environment (Lanyasunya *et al.*, 2001). Age at first calving (AFC) of a heifer is the age at which she becomes a cow and it depends on the rearing system. In the tropics mean age at first calving of heifers ranges from 28.0 to 35.5 months for F1 crosses, high-grade crosses and pure *Bos Taurus* breeds (Kiwuwa *et al.*, 1983). The mean age at first calving of 42 months observed in this study indicates that heifers were calving at a very advanced age. Syrstad (1986) reported that the ages at first calving for *Bos Taurus* and *Bos indicus* breeds were 32.6 and 42.3 months, respectively. An older age at first calving of a heifer is a sign of poor fertility (Stewart, 1995). Heifers were 28% below the target predicted mean mature weight. Based on the predicted weight at first calving, a majority (61%) of heifers were expected to calve at a very light weight. According to the programme a majority of heifers should calve at a weight of 89-100% of their mature weight. The very advanced age at first calving (AFC) of the heifers could be the result of the slow growth rate, which could be associated with poor nutrition and poor herd management.

Poor heifer growth can have a negative impact on milk production and replacement rate. Sejrsen *et al.* (1982) reported that both restricted and *ad libitum* prepubertal nutrition has an effect on maturity and breeding of heifers. Heifers that are feed restricted reach puberty at a delayed age (10± .8 months) and at lower body weight (258±19kg) as compared to those fed *ad libitum* that reached puberty early age (9.7±0.3 months and at heavier body weight (278±11 kg). On the contrary heifers in this study attained mature weight at an advanced age and due to delayed breeding, calved late for the first time. According to Bailey and Murphy (1999) delays in reaching puberty give rise to delayed age at first breeding and age at first calving. As a consequence of the advanced age at first calving, cows have very short production lifetime which leads to low productivity.

Milk production and live weight are also closely related. Well-grown heifers show oestrus early and can be mated at a younger age. Due to the reduced non-productive period, heifers could produce more milk to a given age. Heifers should start lactation with a post-calving weight between 556 and 568 kg and need to add about 22.7 kg body weight per month from birth to first calving or an average daily gain of 0.82 kg/day in order to achieve this (Bailey and Murphy, 1999). On the contrary heifers in this study had low ADGs. Weight change during lactation can also influence milk production. Fisher *et al.* (1983) reported that heifers gaining weight during the first 120 days of lactation produced less milk than those losing weight.

Intercalving period (ICP) is the time gap between two calvings in a cow's life, i.e. between the birth of one calf and her next calf. The mean ICP in this study was 435±88 days whereas, the generally accepted recommended target mean ICP is approximately 385 days. Factors which possibly contributed to the long ICP may be poor data management (record keeping), poor heat detection and poor nutrition (Branton, 1970; Etgen and Paul, 1978; Webster, 1987; Pryce, *et al.*, 2000,). Absence of strict follow-up or herd monitoring could affect the identification or spotting of cows that are in heat and delay the time of insemination or mating. Delayed inseminations could be due to few AI technicians (see chapter 1), inefficient insemination, and other related factors. This study indicated that calving interval spread index and the average services per pregnant cows were 55 and 1.8, respectively, while in a perfectly fertile herd an index of 100 and 1.3-1.6 services per conception would be expected (Stewart personal Communication; Branton, 1970). Thus, in this herd there is a wide spread of calving intervals about the mean, which is another indication of poor management as the most important factor affecting the index is heat spotting success (Bath *et al.*, 1978; Craplet 1963; Reimers *et al.*, 1985).

Furthermore, unpredictable fluctuations in the nutritional status of the herd could result in a poor calving interval index (Ferguson, 1996; Smith and Akinbamijo, 2000). Underfeeding leads to a total lack of ovarian activity and the cow does not come into heat (Purwantara *et al.*, 2001). Lanyasunya *et al.* (2001) reported that dairy cows on a low plane of nutrition, particularly after calving, drain energy from their body reserves which could lead to poor functioning of the ovaries and other glands such as the pituitary. Failure to produce the hormones necessary for the oestrus cycle would then lengthening the period of first service and intercalving interval. In this study the voluntary waiting period (VWP) of 52 days is shorter than the ideal while the mean breeding period is long, leading to a long calving interval. A short VWP of less than 60 days will often lead to short-term pregnancies followed by resorptions with the result that the cow would come into cycle again (The Dairymen, 1994). The long calving interval observed in the herd might not only be as a result of infertile or "problem breeder" cows but also the result of poor management. Cows might not be mated on time due to non-recognition of heat. Poor herd management could be reflected on the overall herd performance. Since body condition and milk production are correlated to each other, low milk production could be manifested due to underfeeding of cows. For instance, the variation observed between the mean and the target milk yield in the herd could be associated with poor nutrition or underfeeding.

The average daily and lactation milk yields of the herd reflect the management levels of the farm. The results indicated that the milk yield of older cows and first calvers was below target milk yield. These low milk yields could be attributed, in part, to the long intercalving period associated with long dry period and short lactation length. Cumulative milk yield at 56, 84 and 300 days in milk showed that most cows are above 75% of the 56, 84, 300 days calculated mean milk yields and thus cannot be considered as inferior but their genetic potential might not be achieved due to poor herd management, nutritional and, other environmental factors. Efficiency ratio is also a good measure of productivity in a herd. It is the kg fat corrected milk (FCM) produced per kg average cow weight. Good herds achieve efficiency ratios of better than 15 (Stewart personal communication). An efficiency ratio of 6.7 observed in this study is lower than half the ideal performance. Milk production is highly correlated with nutrition. Despite the farm using lucerne, elephant grass and limited amount of corn fodder, the bulk of the feed consists of standing hay of poor nutritional quality (low crude protein content). The ration composition usually varies with fluctuations in the availability of ingredients. The system of feeding used in the farm could also affect milk production because all classes of animals were fed with the same ration composition without any regard to the physiological and functional variations.

3.5 CONCLUSION

In conclusion, poor heifer growth rate and poor fertility status in the herd were identified by the study as constraints. Heifer body weights were very poor, as a result they were serviced late. Due to delayed service they calved at an old age for the first time, i.e. advanced age at first calving. Poor heifer body weight might be due to poor nutrition because the feeding system is not satisfactory. Due to poor heifer growth the average status of cows in the herd was below the target, therefore, heifer growth monitoring is required in order to identify the main cause and find a solution. Herd fertility status could be due to factors related to management. As measures of herd fertility, calving interval (CI), calving interval spread index, services per conception (SPC) and other measures of reproductive performance need a strict follow-up in order to cull-out unproductive and problem breeders. Furthermore, nutritional and environmental factors affecting the fertility of the herd should be assessed. Improved herd management that encompasses different aspects, would help to increase herd productivity.

CHAPTER FOUR

GENERAL DISCUSSION, CONCLUSION AND RECOMMENDATION

Dairy systems should be seen as an outcome of diversified and interrelated multi-dimensional processes of development. Technical, social, economical and environmental factors could affect the development of these systems. Observation of existing dairy farms in and around Asmara gave at least a clear picture of the existing diverse systems, however, not all the diverse and complex aspects of the system could be covered within the limited time period of this study. Based on the identified dairy constraints, this chapter will formulate some recommendations.

The present urban and peri-urban dairy systems in Eritrea were acquired as a result of the abolition of the former large-scale dairy farms. This gave rise to the existing system that comprises small and medium sized dairy farms. The dairy system has shifted from one that was land resource (grazing) based to one that is concentrate or by-product based, with dairy cattle being kept under zero grazing systems of management. This is because with the expansion of towns, land is used for residential purposes and thus no grazing is practised.

Based on the general government directives concerning livestock development (FAO, 1994), the following items were among the priorities for livestock improvement: making best use of land according to its ecological potential, keeping livestock numbers in proportion to the carrying capacity, examining the possibilities of cut and carry systems, and improving the efficiency of livestock. The NLDP (National Livestock Development Policy of the MoA, 1996) also outlined research on livestock breeds suitable for local conditions and on improved production techniques is the responsibility of the government (Annex ii), however, due to the absence of a clear breeding policy, most suitable exotic genotypes or grades (cross breeds) at farmers' level are not clearly known so far. Eritrea has no active and clear breeding policy or breeding programme that provides the frame and standards for breeding activities. The MoA in collaboration with DANIDA (Danish International Development Authority) has formulated a dairy cattle breeding strategy but no activity has started (MoA, 1999). Inadequate, inefficient and inconsistent AI services have also contributed to the slow breed improvement programme. As a result, low productivity and low fertility rates were observed in most herds.

Urban and peri-urban dairy farms could be characterised as market-oriented production systems. They contribute significantly towards filling the large demand-supply gap for milk and milk products in the urban centres, where consumption of milk and milk products is remarkably high. Full-time dairying provides employment opportunities and supplies protein to the population in Eritrea. Part-time dairying provides additional income and improved nutrition for the population. In similar studies, Egziabher (1994) reported that urban agricultural activities appear to provide practical solutions to some of the major income shortage problems, poverty, unemployment, and food insecurity faced by the urban low-income population in Addis Ababa, Ethiopia.

The inadequate supply of milk to the urban centres in Eritrea shows that there is a need to develop urban and peri-urban dairy systems (see Chapter 1). Currently milk control and legal instruments are practically non-existent, or at least not effective. Milk delivered to Asmara dairy plant where it is subjected to heat treatment and quality control is considered as legally marketed milk, while that marketed directly to individual households, tea rooms, bars and restaurants is considered as illegally marketed milk. Even though milk produced by urban and peri-urban dairy farms can be marketed through informal channels to local traders and individual consumers, public health safety precautions are also necessary. From public health point of view, milk should be free of any disease and milk quality control should cover all stages from production to consumption. The MoA introduced a quota system of feed distribution as a control mechanism for milk quality because no standard of quality exists. Farmers would only be allowed to purchase concentrate feed through the ASMDFCA on the condition that they supply milk to ADP. Even though the system might serve as a control mechanism, it could impede progress, expansion and sustainability of the dairy production system.

The total farm milk production is related to the total number of milking cows kept on a farm, i.e. the larger the herd size the higher the total farm milk production. However, individual cow milk yields are higher on farms with small herds. This could indicate the existence of differences in herd viability or efficiency. An increase in total farm milk production not only requires an increase in herd size but it could also demand more extra input.

Prevalence of economically important diseases might be related to poor veterinary service and inadequate supply of drugs. Farmers postulate that the prevailing inadequacy of the service is related to a shortage of enough mobile veterinarians who can regularly visit dairy farms. It was observed that the veterinary clinics were understaffed. The lack of veterinary drugs aggravated the situation because drugs are distributed only by the government, there being no private veterinary pharmacies. Even though the government supplies veterinary drugs, dairy farmers claim that the prices of some drugs are high and not affordable.

4.1 CONCLUSION AND RECOMMENDATION

To ensure high productivity and profitability of a dairy system, appropriate feed and feeding management, health care and reproductive management are essential. The ability to cope with challenges and competitive features allowing for intensification could determine survival and sustainability of urban and peri-urban dairy systems. Some policy issues need to be addressed. Land access needs special emphasis because urban and peri-urban dairy farmers cannot improve and expand productivity further if they do not have access to land both for forage production and housing.

Lack of co-ordination does not mean the total absence of linkages among the stakeholders at all but it rather implies the existence of a communication gap or absence of a strong linkage network (Steele, 2001). No strong linkage network existed among stakeholders of the system; as a result there is lack of knowledge and information transfer. It might be concluded that there is little or no well-developed formal and informal organisational structure that could facilitate communication and flow of information among stakeholders in the dairy system.

Since a dairy production system requires co-ordinated activities, intervention should focus on social, technical, and economic aspects of the system. Even though it is difficult to improve the system instantly, recommendations drawn from this study encourage good planning and concerted research: Thorough investigations should be conducted to determine the causes of the observed variability in dairy production. This could help to evolve interventions for specific groups of producers.

Interaction among stakeholders through the dairy advisory service determines the level of information exchange and transfer of knowledge. A strong linkage will also enhance smooth information flow. Therefore, conducting training of extension officers and dairy farmers by organising workshops and/or creating other forums is highly required.

The demand of the population for dairy products is not being met due to scarcity of resources and low productivity of dairy cattle, therefore, research is required to determine sustainable and viable herd sizes and strategies for increasing milk production efficiency. Current feeding systems used by farmers cannot guarantee fulfilment of nutritional requirement of animals, therefore, research on existing feed resources is required to design national strategic intervention in dairy feeding and nutrition.

Although the NLDP (Annex ii) clarified privatisation of livestock services as a strategy, veterinary and AI services are still under the hands of the government and hence privatisation of livestock services has not yet been implemented. As a result, animal health and AI services have remained at their lowest stage. The present animal health service needs to be improved both in terms of drug and vaccine availability. Similarly, a sufficient number of fully equipped mobile technicians is required to implement this service. The issue of privatisation and handling of services was also raised by ASMDFCA as a solution for veterinary service shortfalls and drug shortage. Currently, ASMDFCA cannot go beyond milk collection and feed distribution to its members because of the shortage of skilled manpower. While ASMDFCA develops capacity to deliver these services instead of the government, it is recommended that: the private sector should be capacitated gradually to render the service and supply of other dairy inputs. Clear guidelines should be formulated to decide which services should be handled by farmer co-operatives and other stakeholders. For successful handling of livestock services, adequate practical training of farmer co-operatives is also required.

Elabered dairy, being the only large-scale commercial farm, is believed to serve as a prototype and could contribute in fulfilling the existing milk supply gap for the population. In addition, it could serve as a source of improved genotype for urban and peri-urban dairy farmers. To alleviate the identified constraints, feeding, health, breeding (mating), calf management and heifer growth monitoring and overall herd performance assessment and diagnosis are recommended.

In order to have disease-free herds and to avoid environmental and public health hazard, land should be allocated for housing and forage production. This also requires changes to the land use policy that encourage dairy farmers to increase investment. Generally, a sustainable dairy development strategy based on the participation of all relevant stakeholders needs to be designed in such away that dairy farmers, policy makers, feed producers and others are involved in problem identification and analysis, design, implementation, monitoring and evaluation of the programme.

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Annexures

Annex I

SURVEY QUESTIONNAIRE

Name/Farm number ________________________________

Location ____

Type of Management □ **indoor or closed barn** □ **outdoor/grazing** □ **both**

Herd composition/Structure and Breed

Age group	Breed or Type						Total	Remark
	Local	No.	Exotic	No.	Cross breed	No.		
Cows								
Milking								
Pregnant								
Non-pregnant								
Dry cows								
Pregnant								
Non-pregnant								
Heifers at br.age								
Calves								
Weaned								
Unweaned								
Breeding bulls								
Bulls used for other purposes								
Breed total								

I. General farmers' information

1) What are the main feed resources used?

Green forage **Yes** □ **No** □ If yes, is it cultivated or purchased? If purchased how much does it cost per tone? ____________________________

If cultivated how much does it cost to cultivate a hectare? ______________

Hay/straw **Yes** □ **No** □ If yes, is it harvested or purchased? ______________

Grazing **Yes**□ **No**□ If yes, from where? Own land or others (rented)____

Vegetable waste **Yes**□ **No**□ If yes, specify source and price per tone

____

Agro Indus. Byproduct **Yes** □ **No**□ If yes, specify source, type and price per tone

Source	Type	Price/100kg	Amount/month
Private			
Coop's			
Gov't agent			
Own production			
Etc.			

Commercial concentrates **Yes** □ **No** □ If yes, specify source, type and price and quantity.

____

____

Do you think it is enough and is sold at a reasonable price?

____

If not, what do you suggest?

____

____

____

What are the other sources of feed for dairy cattle?

____

____

____

____

How much do you spent for each of the feeds used per month?

____

____

____

____

2) What type of mating do you use for your dairy cows?

(a) Bull service **Yes**□ **No**□ If yes, how much do you pay per service and for how many times if the cow doesn't conceive?

____

____

____

(b) A.I. **Yes** □ **No** □ If yes, how much do you pay for one service & for how many times?

____

____

____

____

(c) Who supplied the A.I.service? _________ Do you think it is efficient? **Yes**□ **No**□ If not, what do you suggest?

____

____

____

(d) Does the A.I. service have consistency? **Yes**□ **No** □ If no, what is the main reason?

____

____

(e) Time of breeding **Year round** □ **Seasonal** □

(f) Historical information for A.I. (MoA).

- What are the methods/signs used to detect heat (estrous)?

  ____

- Time of heat detection____
- Time of calling inseminating technicians ______________________________
- The actual insemination time ______________________________

(g) Number of inseminations/services given per

- Year ______________________
- Month ______________________
- Date ______________________
- What is the number of people who are using A.I. service for their cattle per year?

  ____

- How many calls were there per farm per year? ____________________
- How is the distribution of the A.I. centres with respect to the dairy farms (number of A.I.centres)

  ____

  ____

- Source of semen

  1.Previous______________________________

  2.Present ______________________________
- Semen freezing facilities used______________________________
- Means of transport used ______________________________
- Number of A.I. technicians through time (since the service is fully introduced to dairy farmers upto the present) **Increasing**☐ **Decreasing** ☐ **Remains constant**☐

3) What other inputs do you do for your dairy farm?

a) Housing **Yes** ☐ **No**☐ If yes, what kind of housing system?

   ____

   ____

   ____

b) Do you have enough land area/ animal? **Yes** ☐ **No**☐ If no, how do you keep your dairy cattle?

   ____

   ____

   ____

c) What kind of construction material do you use for the dairy house?

   ____

   ____

d) How much does it cost you to construct the dairy house? Do you think it is economical? **Yes**☐ **No**☐ If no, what other options do you suggest & why?

   ____

____

____

____

____

____

e) Veterinary care

Have encountered any disease problems in your herd? **Yes** □ **No** □ If yes, which are the most prevailing diseases in your farm?

____

____

____

____

____

____

____

Do you have access to veterinary service? **Yes** □ **No** □ If yes, do you think the service is enough and efficient? **Yes** □ **No** □ If no, what do you think the main shortcomings are? What measures do you suggest to improve the service?

____

____

____

____

____

____

____

Do you get enough veterinary drugs and at a reasonable price?

Yes□ **No**□ If yes, state the source

____

If no, what do you think the solution will be?

____

____

When are the critical seasons for the diseases to be seen in your herd?

____

____

____

____

Do you use any traditional way of treating your animals? Yes ☐ No☐. Do you often report to the concerned vet. Office? **Yes** ☐ **No** ☐ If yes, how quick is their response? If no, why not? ____

What traditional medicines do you use for which disease?

____

4) What is the main source of stock for your herd?

(a) Rear replacement heifers myself ☐

(b) By replacement heifers from other farmers ☐

(c) Exchange heifers with other farmers ☐

(d) Buy adult cows ☐

(e) How often do you replace your stock and why? __________________**Age** ☐

Disease ☐ **Low production** ☐ **Other reasons** ____________________

(f) What is the main reason (priority) for you to keep dairy cattle?

HH milk source ☐ **Cash income**☐ **Means of employment & livelihood** ☐ **Hobby** ☐

(g) What is your attitude to keep dairy cattle? /future strategy concerning keeping dairy cattle?

Saving☐ Cash income☐ Support crop farming☐ Others☐

Milk Production and Marketing

1) What is the average milk production per one cow per day in litres? __________.

2) For how long (months) do you milk your cows?

____

3) Total milk produced per year (litres) i.e. herd average ____________________.

4) What do you do with the milk produced?

(a) How many litres do you sell? ________________________________.

(b) To whom do you sell?

Informal Direct to consumers

Neighbours **Yes**☐ **No** ☐

Relatives **Yes**☐ **No** ☐ If yes, how much do you sell direct to consumers and on what price? Why?

____

____

How do the consumers rate your milk in comparison to the pasteurized milk sold by the dairy plant? **Watery☐ Low fat ☐ Easily perishable ☐**

Formal To dairy plants **Yes☐ No ☐**

If yes, how much do you sell to the plant and on what price per litre of milk?

____

____

____

If you are selling to the dairy plant how do you transport your milk from the farm to the plant?

____

____

What is the basis of receiving milk for the dairy plant?

____

____

Do you think the price paid per litre of milk is attractive/ enough? **Yes☐ No☐**

If no, what do you suggest?

____

____

____

____

Does the dairy plant receive all the milk supplied at any time of the year?

Yes ☐ No☐ If no, what is the reason and what do you do then?

____

____

____

(c) Do you use milk for household (HH) consumption? **Yes ☐ No ☐** If yes, how much is consumed at home? ______________________________.

(d) Do you get any surplus milk? **Yes☐ No☐**

If yes, how much? _____________ and what do you do with it?

____

Do you have any traditional churner at home? **Yes☐ No ☐** If no, what do you think to introduce mini churner (mechanical/ manual) at home

Is the surplus milk you get seasonal or continuous? If seasonal which season?

Is there any milk collection centre in your locality? **Yes** □ **No** □ to whom does it belong?

Government □ **Private** □ **Community**□

How do you see its importance and why?

Very high □ **High** □ **Medium** □ **Low** □

IV.Constraints/ Problems

Have you encountered any problems/ constraints with the dairy operation?

Yes□ **No** □ If yes, what are the main constraints?

____

____

____

____

____

____

____

____

____

What can be done to solve the problems (constraints)? Farmers' opinion

____

____

____

Group survey

Pair wise ranking of Problems

Problems	1	2	3	4	5	6	7	8	9...
1									
2									
3									
4									
5									
6									
7									
8									
9...									

<u>Annex II</u> Livestock Development Policy formulated 1993 and revised 1996

1. The government aims to promote the development of the animal resources in order to increase the supply of animal products, increase animal draught power, improve food security, generate income and employment, and contribute to industrial development and the country's balance of payments.

2. Government involvement in the animal resources sector will be directed towards increasing productive efficiency, especially among smallholders.

3. Government will undertake appropriate animal research programmes in animal nutrition, breeding, husbandry and health aimed at increasing animal productivity and production in the various ecological zones.

4. In order to streamline and improve the effectiveness of the delivery of livestock services and the implementation of the public activities in this sector, the government will aim to strengthen the ability of regional livestock services to work from village level upwards.

5. The government will endeavour to ensure that prevention and control measures against economically important diseases are implemented throughout the country in order to significantly reduce losses to enable animal products penetrate the international markets.

6. The government will take the responsibility for the control of nationally important diseases, particularly Class 1 scheduled diseases such as rinderpest, foot-and-mouth disease (FMD), contagious bovine pleuro-pneumonia, (CBPP) and rabies and/or any other disease that may require state intervention in the national interest.

7. Clinical treatment, vaccination and inoculations against other scheduled diseases (such as hemorrhagic septicaemia, brucellosis, Newcastle, African horse sickness, and trypanosomiasis) and activities such as Artificial Insemination (A.I.), bull testing will be the responsibility of the individual farmer.

8. The government will provide facilities for laboratory diagnostic services for all diseases but farmers will have to pay for them except in the case of nationally important diseases or those that threaten the national interest.

9. The government will be responsible for all aspects of veterinary public health services such as the inspection of meat and meat by-products, milk hygiene, quality control of animal-derived foodstuffs, and the controlled use of veterinary drugs.

10. Existing laws and regulations will be reviewed, and the government will introduce new legislation to accommodate the privatisation of the delivery of services to livestock producers.

11. The government will encourage private veterinary practice and community-based animal health care in order to give farmers access to animal health and production services.

12. Fiscal and budgetary constraints hindering the public delivery of livestock services will be addressed through the design and implementation of cost recovery systems.

13. Research on livestock breeds suitable for the local conditions, and on improved production techniques will be the responsibility of the government.

14. The government will ensure appropriate land-use planning in order to improve animal nutrition through the allocation of adequate grazing lands in the various ecological zones, with emphasis on the lowlands.

15. The government will facilitate private sector processing and export of animal products based on a high standard service.

Annex III

Pictures showing housing, feed mixing, feeding, body condition and milk cooling

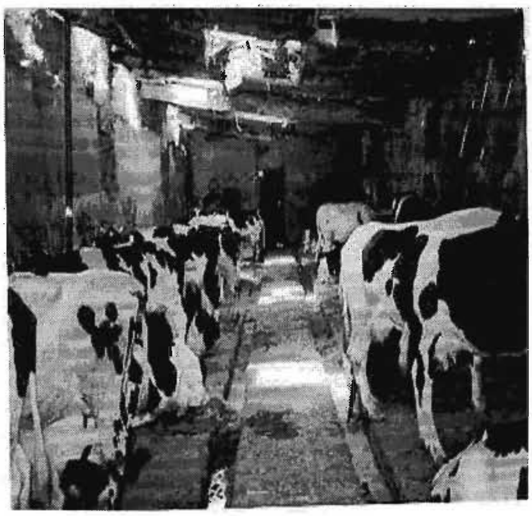


Plate 1&2: Housing system (tie and closed barn)

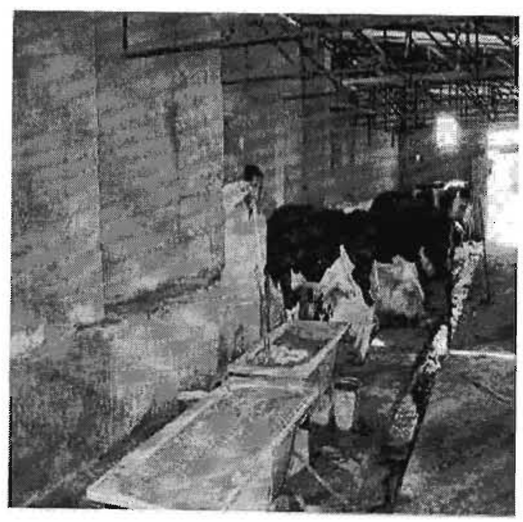


Plate 3 & 4: Mixing and soaking in water of all available feeds together

Plate 5&6: Soaked feed ready for feeding to cattle

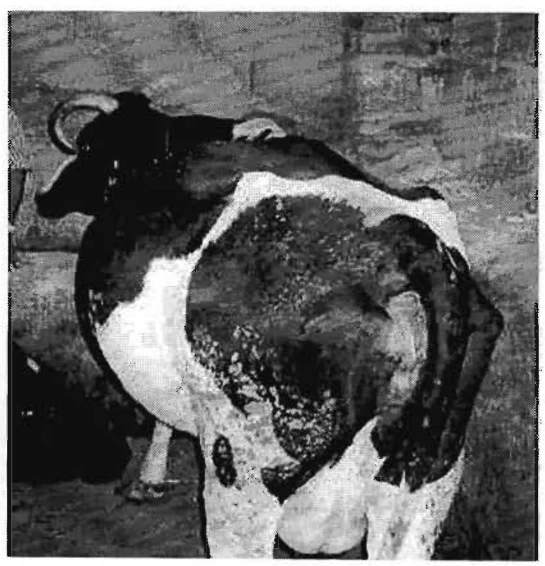


Plate 7& 8: Digital problems /lameness (left) and distended rumen /bloat (right).

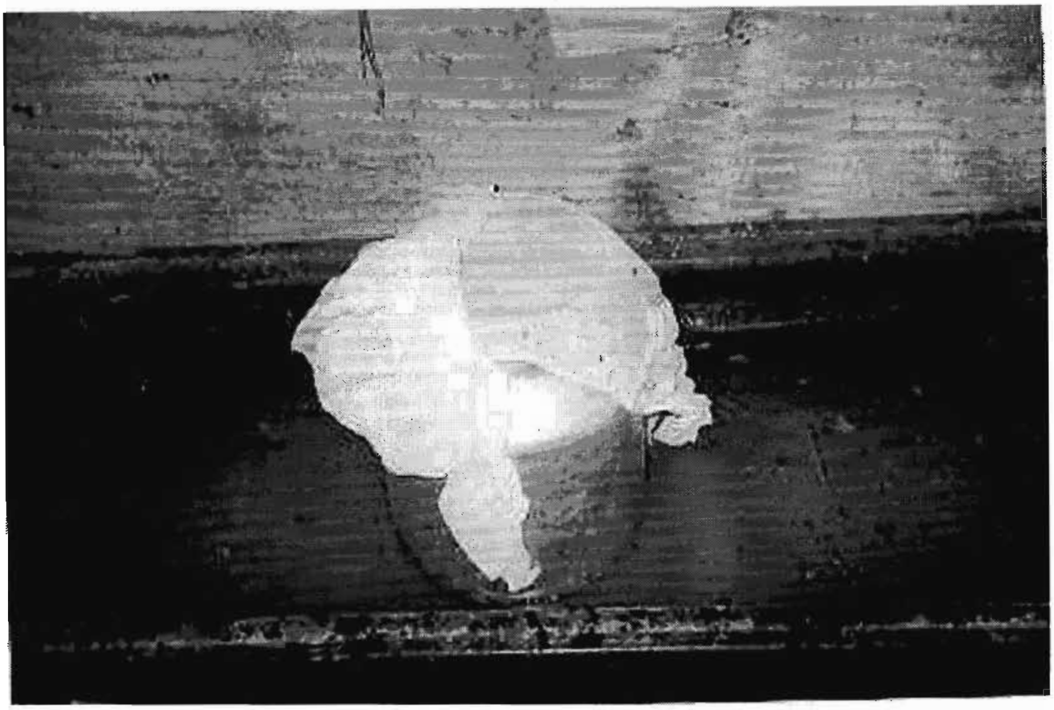


Plate 9: Milk can immersed in water for cooling the milk.

Annex IV

CONDITION SCORING OF DAIRY COWS

DEFINITIONS, GRAPHIC AND PHOTOGRAPHIC STANDARDS

SCORE 0

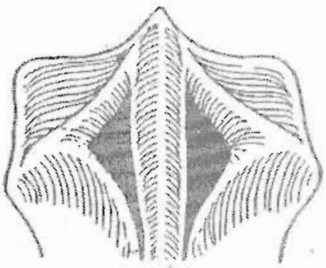
Condition: Very poor

(A) Tailhead area

Deep cavity under tail and around tailhead. Skin drawn tight over pelvis with no tissue detectable in between.

(B) Loin area

No fatty tissue felt. Shapes of transverse processes clearly visible. Animal appears emaciated.



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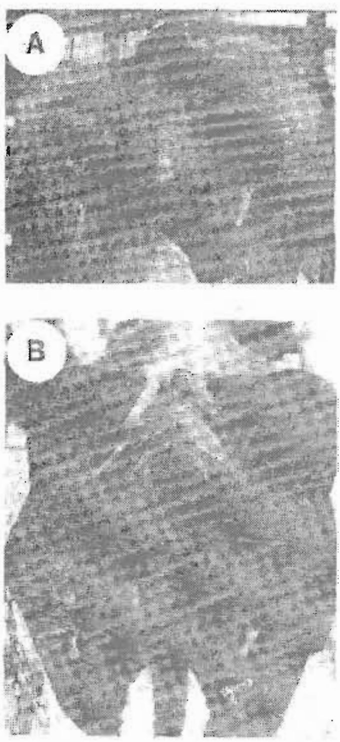


SCORE 1

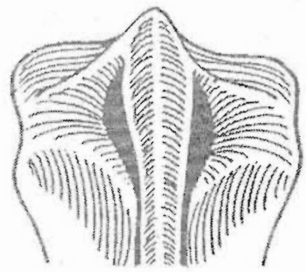
Condition: Poor

(A) Tailhead area

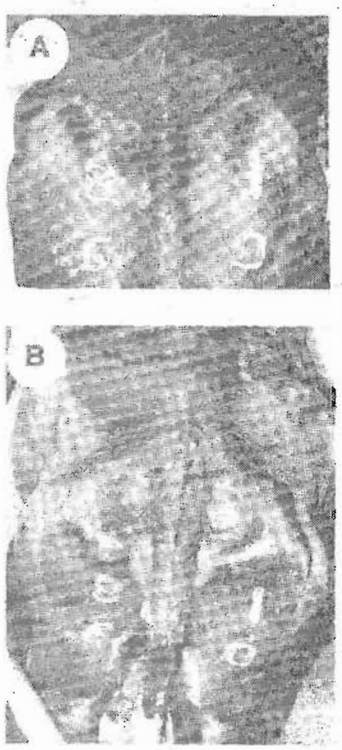
Cavity present around tailhead. No fatty tissue felt between skin and pelvis but skin is supple.

(B) Loin area

Ends of transverse processes sharp to touch and upper surfaces can be felt easily. Deep depression in loin.



1



SCORE 2

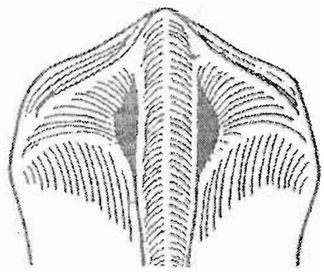
Condition: Moderate

(A) Tailhead area

Shallow cavity lined with fatty tissue apparent at tailhead. Some fatty tissue felt under the skin. Pelvis felt easily.

(B) Loin area

Ends of transverse processes feel rounded but upper surfaces felt only with pressure. Depression visible in loin.



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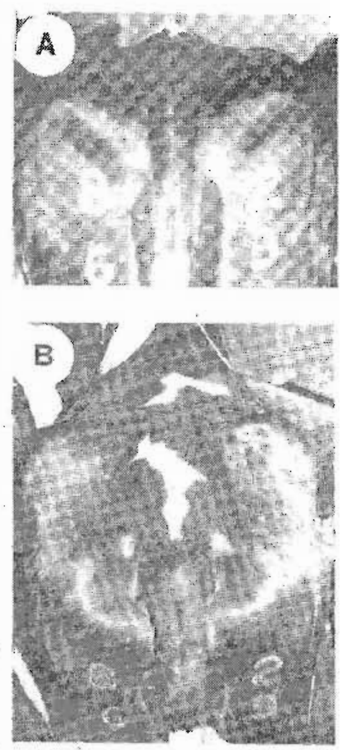
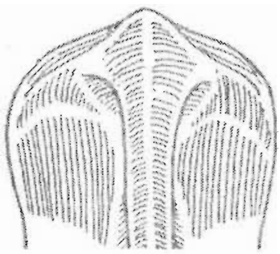


SCORE 3

Condition: Good

(A) Tailhead area
Fatty tissue easily felt over the whole area. Skin appears smooth but pelvis can be felt.

(B) Loin area
Ends of transverse processes can be felt with pressure but thick layer of tissue on top. Slight depression visible in loin.



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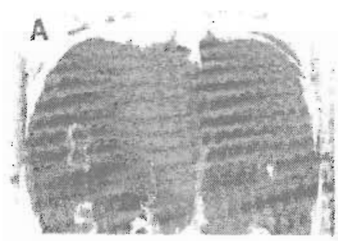
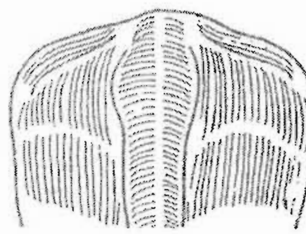


SCORE 4

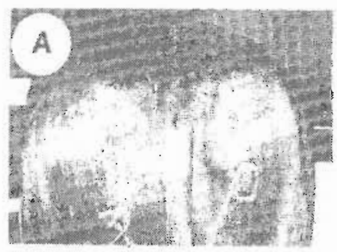
Condition: Fat

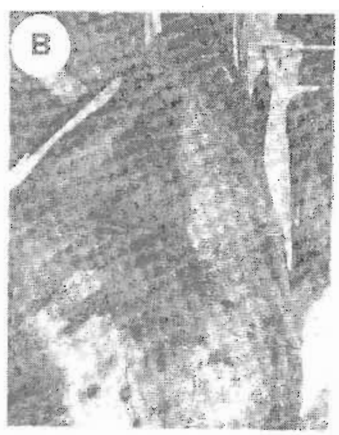
(A) Tailhead area
Folds of soft fatty tissue present. Patches of fat apparent under skin. Pelvis felt only with firm pressure.

(B) Loin area
Transverse processes cannot be felt even with firm pressure. No depression visible in loin between backbone and hip bones.



4



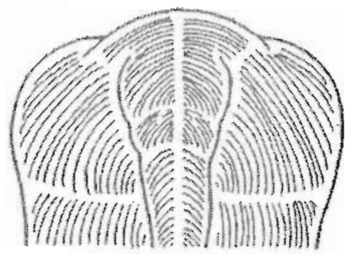


SCORE 5

Condition: Grossly fat

(A) Tailhead area
Tailhead buried in fatty tissue. Skin distended. No part of pelvis felt even with firm pressure.

(B) Loin area
Folds of fatty tissue over transverse processes. Bone structure cannot be felt.



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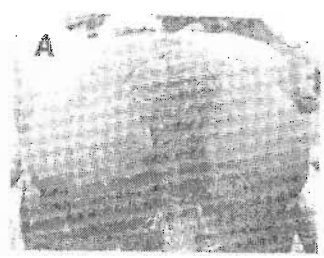

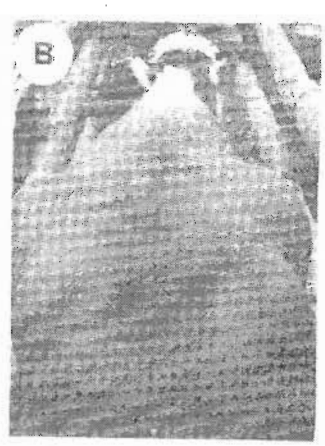

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