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Improving the management of dairy production systems in Cameroon

by

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Philosophiae Doctor

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DEDICATION

To my dear wife Judith who has supported me during this work in a special way. To my children: Longè, Charles-Dimitri, Anwarite, Lipem and Beau.

To my brothers nicknamed Baba, Type, Vieux and sister Aimée. Lastly to my parents without whom I could not be what I am today: Bayemi Charles and Ngo Pougue Marthe.

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DECLARATION

I declare that this thesis for the degree of Philosophia Doctor (Faculty of Agriculture, department of Animal and Wildlife Sciences) at the University of Pretoria has not been submitted by me for any degree or exam at any other university.

Signature..

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ABBREVIATIONS

AI:	**..................**	Artificial insemination
BCS:	**..................**	Body condition score
C-ELISA:	....	Competitive Enzyme Linked Immunosorbent Assay
CL:	**..................**	Corpus luteum
ECM:	**..................**	Energy Converted Milk
ELISA:	**..................**	Enzyme -Linked Immunosorbent Asay
EOS:	**..................**	Economic Opportunity Survey
FAO:	**..................**	Food and Agriculture Organization
FMD:	**..................**	Foot and mouth disease
GDP:	**..................**	Gross Domestic Product
GLM:	**..................**	General linear models
HPI:	**..................**	Heifer Project International
IAEA:	**..................**	International Atomic Energy Agency
ILCA:	**..................**	International Livestock Centre for Africa
ILRI:	**..................**	International Livestock Research Institute
IMVT:	**..................**	Institut de Médicine Vétérinaire des pays Tropicaux
IRAD:	**..................**	Institute of Agricultural Research for Development
IRZ:	**..................**	Institut de Recherche Zootechniques
lsmeans:	**..................**	Least square means
mAb:	**..................**	Monoclonal antibody
MINEPIA:	....	Ministère de l'Elevage, des Pêches et des Industries Animales
MINPAT:	....	Ministère du Plan et de l'Aménagement du Territoire
MPT:	**..................**	Multipurpose trees
ng	…………...	Nanogrammes

nmol	………... ...	Nanomoles
NGO:	**..................**	Non-Governmental Organization
OIE:	**..................**	Office Internationale des épizooties
PDA:	**..................**	Potato-dextrose agar
PRA:	**..................**	Participatory Rural Appraisal
RIA:	**..................**	Rradioimmunoassay
S-LPS:	**..................**	Smooth lipopolysaccaride
SPCA:	**..................**	Standard Plate Count Agar
TBC:	**..................**	Total bacterial count
TDCS:	**..................**	Tadu Dairy Cooperative Society
USAID:	**..................**	United States Agency for International Development
VRBA:	**..................**	Violet red bile agar

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PUBLISHED PAPERS

The following papers produced from this thesis were published or accepted in peer reviewed journals, or presented in scientific conference.

1. **Bayemi, P. H., Bryant, M. J., Perera, B.M. A. O., Mbanya, N. J., Cavestany, D., Webb E. C., 2005.** Milk production in Cameroon: A Review. Livestock Research for Rural Development 17 (6). www.cipav.org.co/lrrd/lrrd17/6/cont1706
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5. **Bayemi , P. H., Webb ,E. C., Manjeli ,Y., Naoussi , P., 2007.** Economic Opportunity Survey of Small Scale Dairy Farms of the North West Province of Cameroon. Tropical Animal Health and Production, 39:583-592
6. **Bayemi, P. H., Munji, V. N., Cavestany, D., Perera, B. M. A. O., Webb, E. C. 2007.** Validation of a human progesterone EH511 Enzyme Immuno Assay kit for use in cattle serum at Bambui, Cameroon. Tropical Animal Health and Production, 39: 335-338.

7. **Bayemi, P. H., Cavestany, D., Bryant, M. J., Munji, V. N., Webb, E. C., Ngo Lihep, M., Perera, B. M. A. O., Whiteker, D., Mbanya, J. N. , 2007.** Factors affecting return to oestrus and milk production in lactating cows of small holder dairy farms of Bamenda, Cameroon. 3R , Rencontres-Recherche-Ruminants, conference Paris, 14e Journée, Dec 2007. http://www.journees3r.fr/texte.php3?id_article=2553

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SUMMARY

Title: Improving the management of dairy production systems in Cameroon

Candidate: Bayemi Pougue Henri Dieudonné

Supervisor: Prof E.C. Webb

Department: Animal and Wildlife Sciences

Degree: Philosophiae Doctor

This work was carried out with the objective of improving dairy farms in Cameroon using an integrated method. Research done in the area on milk production in the country was reviewed. A participatory rural appraisal was conducted in dairy farms of the North West Region of Cameroon. An economic opportunity survey was carried out on 61 dairy farms in the same region. Interventions aimed at solving main constraints were planned. An on-farm study on the effect of feed supplementation before calving on milk production, ovarian activity and calf growth of Holstein, indigenous Red Fulani cows and their crosses was conducted. Corresponding blood samples were analyzed using ELISA Progesterone kits. Animal health studies involved screening for *Brucella abortus* antibodies in 21 villages by ELISA. Partial budgeting was used to evaluate the financial impact of interventions.

Results show that five small scale dairy production systems are found in the region: transhumance, improved extensive, semi intensive, zero grazing and peri-urban. Main constraints to dairy production include in order of importance: poor marketing opportunities and long distances to market, limited grazing land and poor supplementation of cattle, limited health control, inadequate knowledge in processing, conservation and storage of milk, poor reproductive management and prolonged calving interval, lack of water in the dry season, poor housing, poor organization of group, limited number of dairy cows and poor record keeping. Milk production per cow on-one-day and average calf production interval account for the greater part of economic opportunity. A human progesterone ELISA kit was validated for use in cattle. *Brucella* screening showed a general seroprevalence of 8.4%. It is recommended that infected cattle should be slaughtered. A specific control programme should be organized and an effort should be made to determine the causes of the spread of brucellosis. A regular *Brucella* testing should be instituted. Farmers adopting interventions had returns of 193 and 232% without and with opportunity costs proving the positive impact of interventions using the integrated method. These interventions need to be spread to more farms in the country.

The integrated method was proven to be effective in ensuring improvement of dairy systems in Cameroon. This method needs to be adopted for further dairy production improvement by the creation of multidisciplinary intervention teams and the training of integrated intervention specialists in the dairy sector.

Key words: Cameroon, Integrated method, Interventions, Small holder dairy

CHAPTER 1

1. General introduction

About 25,000 people die every day of hunger or hunger-related causes, according to the United Nations (www.wfp.org), particularly in Africa. In Cameroon life expectancy at birth is estimated to be 51 years. In 2006 the under-five mortality rate was 150 deaths per 1,000 live births. Poverty is rampant in the country as 50% of the population live below the national poverty line (World Bank, 1999). Prevalence of malnutrition increased from 16% to 23% between 1991 and 1998, rising from 13% to 15% in urban areas, and from 19% to 25% in rural areas (Pongou *et al*, 2005) with a prevalence of 22% in children less than 5 years of age. One way of combating extreme poverty is to improve agricultural production because about 75% of the active population is involved in agriculture, which accounted for 50% of total exports (Wolfgang, 1997) and about 22% of GDP in 2000. The dairy cow is known to be one of the smartest investments a farmer can make in terms of income generation (ILRI, 2003). Due to urbanization and population growth, milk production should double by the year 2020 if it is to meet demand (Ndambi *et al*, 2006).

Already, self sufficiency in milk products in Cameroon only stands at 76%, while 24% of the national consumption is imported (Ndambi and Bayemi, 2006). Therefore, there is a need to improve domestic milk production (Figure 1.1).

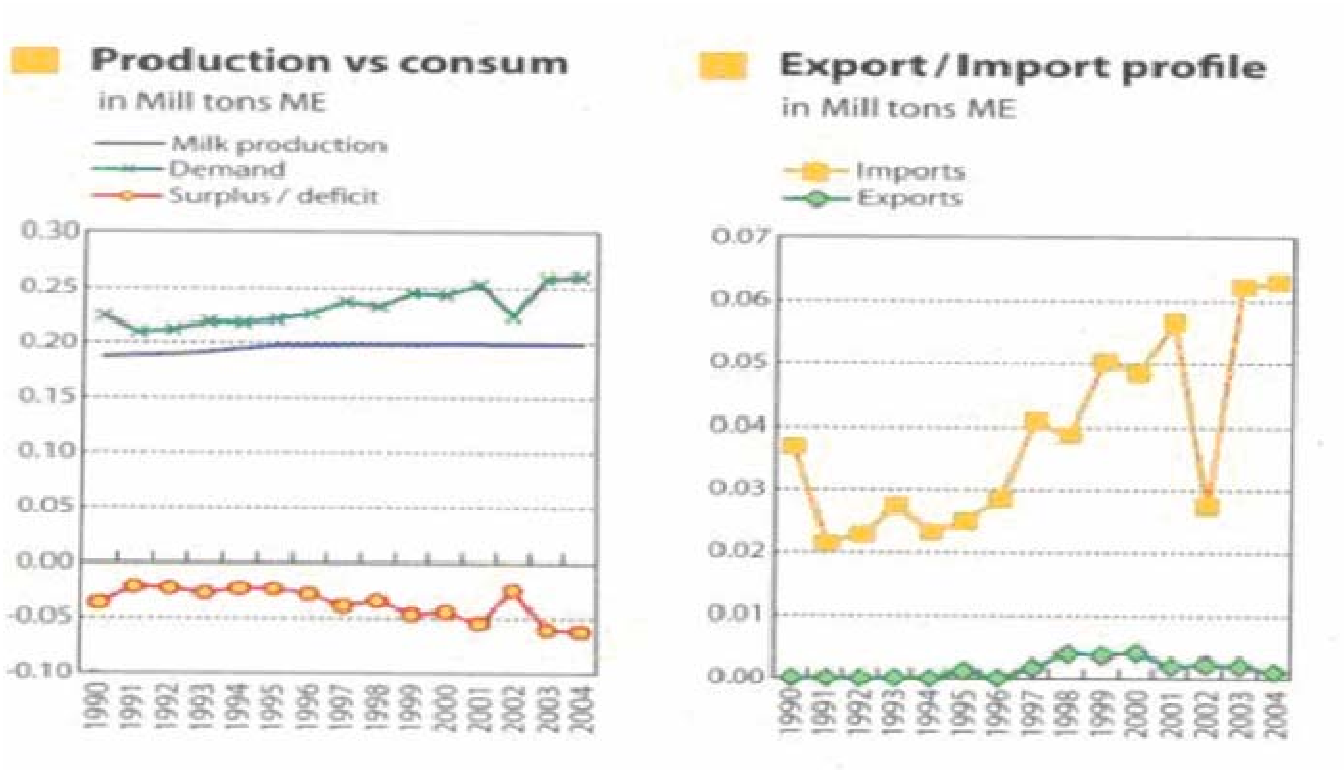

Figure 1.1. Production vs consumption and import/export profile of milk production in Cameroon, in million tons ME (ECM) (Ndambi *et al*, 2006)

The Republic of Cameroon is located in Central Africa and ranges from the equatorial forest to the Sahelian zone in Lake Tchad with a total land area of 475 440 km^2 and a human population of 16.2 million (Ndambi *et al*, 2006). The population is expected to reach 20.5 million in 2010 (Njoya *et al*, 1999). It is administratively divided into 10 regions covering five agro-ecological zones. The four administrative regions that have been particularly associated with dairy production in Cameroon are the Adamaoua, North, Far North and the North West. The latter is more suitable to dairy production as it has milder temperatures and is free of Tse Tse flies.

Three systems have been associated with cattle production in Cameroon. First, the extensive or traditional system which for centuries has been carried out by the Fulani pastoralists; in this system, milk is considered as a by-product of beef production using breeds such as the Gudali, Red Fulani and White Fulani (*Bos indicus*). The animals graze on native pastures of *Sporobolus africanus, Pennisetum purporeum* and *Melinis multiflora*. Milk off-take starts from 1 to 3 months post-calving and varies between 0.5 to 3 litres per cow per day. Calves are usually weaned at 10.5 months. In the semi intensive systems, crossbred animals are used (*Bos taurux X Bos indicus*). Fencing is common as is rotational grazing. Pastures are improved with planted grasses, legumes and multipurpose trees, including grasses like *Brachiaria spp, Trypsacum laxum and Pennisetum clandestinum*. Cattle are also fed on by-products, waste food and fruits such as sugar cane leaves, potato leaves, guavas, ripe bananas, pumpkins and waste cooked corn. Crop residues include: corn stovers, banana pseudo stems and leaves, ground nuts and bean haulms. In this system cows give an average of 12 litres per cow per day at the peak of the lactation curve. The intensive system involves the use of purebred Holstein cattle in a zero grazing, cut and carry system, at often 1 to 2 cows per farm. The following ingredients are commonly used in supplementation on semi intensive and zero grazing cows: Maize, rice bran, wheat bran, palm kernel cake, cotton seed cake, whole soya beans, bone ash, limestone and table salt. Purebred calves are given colostrum, then bucket fed and weaned at 4 months of age. At peak lactation, cows can produce up to 25 litres per cow per day.

Constraints to dairy production in all systems include: low nutritive value of pastures and inadequate pasture management (Njoya et al, 1999); unavailability of dairy cows, long calving to conception periods, low heat (oestrus) detection, presence of ticks and tick-borne diseases, high cost of veterinary services, lack of cooling facilities for milk, the poor access of farmers to resources and information (Ndambi *et al*, 2008), limited milk for processing and consumption in urban areas.

These constraints limit milk production which declines at 1% per farm per year (Ndambi and Bayemi, 2007). There have been a number of results from studies aimed at improving small scale dairy production based on improved feeding, reproduction, health and management (Mbanya *et al*, 1995; Kamga *et al*, 2001; Bayemi *et al*, 2005a; Bayemi *et al*, 2005b; Ndambi *et al*, 2006; Bayemi *et al*, 2007).

However, the uptake of these results by wider communities of farmers, farmers' organizations and livestock extension services has been less than expected. It is becoming clear that the major reason for this is a failure to demonstrate the advantage in economic terms to the farmer because emphasis was on biological improvements. In addition, previous initiatives failed to show the farmer the real gains that could be made, because they focused only on one constraint at a time, and other concurrent production problems limited the economic benefits. This in turn resulted in interventions for supplementary feeding, or for improving reproductive performance that did not demonstrate an economic benefit to the farmers. Therefore there is a need for the development of an integrated approach that addresses the major production constraints simultaneously, generates significant profit (Perera, 2007) and ensures sustainability.

This development requires a comprehensive knowledge of milk production systems in the country, an investigation in reproductive and feeding problems, a study on the milk quality and an attempt to solve the existing constraints by applying specific interventions. The research was conducted within the framework of a thesis. The results are presented as articles on specific topics, most of which have been published in scientific journals with peer review.

The main objective of this work is to develop an integrated method to ensure sustainability and improve dairy farms. Work on specific objectives is reported in chapters on: the review of studies on milk production in Cameroon; the participatory rural appraisal and economic opportunity survey of dairy herds in Cameroon; the study of progesterone profiles of cattle breeds used for milk production; investigation on the effect of pre-partum supplementation on post-partum ovarian activity; study on brucellosis; setting up of interventions aimed at improving milk production and an evaluation of the impact of these interventions.

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CHAPTER 2

2. Literature review

Milk production in Cameroon

Published in Livestock Research for Rural Development

Bayemi, P.H., Bryant, M.J., Perera, B.M.A.O., Mbanya, N.J., Cavestany, D., Webb, E.C., 2005. Milk production in Cameroon: A Review. Livestock research for rural development 17 (6). www.cipav.org.co/lrrd/lrrd17/6/baye17060.htm

2.1. Abstract

For centuries, milk production in Cameroon has been characterized by the traditional system using local zebu cows (Gudali, White Fulani, Red Fulani). However, this production has been insufficient reaching only an average of 3 litres per cow per day. Per capita annual consumption was 10kg in 1984. Since then improvement in production has been possible thanks to importations of high yielding breeds such as Holstein Friesian, Jersey and others. This gave room to other semi intensive and intensive production systems in such a way that in 1998 per capita production was 12.8kg. This is still far below 34kg per person for Africa and 294kg per person for Europe. In this study, research done in the area on milk production was reviewed. Constraints to increase production were summarized and proposals are made for the sustainable development of the dairy sector

Key words: Cameroon, cattle, dairy, milk, review

2.2. Introduction

Africa's human population is growing at a rate of 3.1% per year (Ndituru, 1993). This population growth is prompting many governments to aim at a policy of food self sufficiency. Although efforts are being made to increase agricultural production, malnutrition is still a plague in many parts of the continent. Protein and micronutrients deficiencies continue to be persistent (Delgado *et al,* 1999). Over 800 million people worldwide suffer from malnutrition and hunger not only due to low food production and unequal distribution but also because poor people lack the income to acquire adequate quantities and qualities of food (Wilson *et al*, 1995). People of Sub-Saharan Africa consume foods that consist mainly of starch and oil. Milk and milk products, if sufficiently available, could efficiently correct these deficiencies and be part of most Africans' diet. Besides improving nutrition and health of all members of the household, dairying also increases farmers' incomes (ILRI, 1998). However, in 1999, per capita production of whole fresh milk in Africa was only 34kg /person compared to 294kg / person in Europe (adapted from FAO, 2000) with very large variations of consumption among regions of the same country. Such a deficit makes milk products expensive and not available to most people. This is seen in urban areas where prices go up in the hot season because of the shortage of milk from pastoralists (Kameni *et al*, 1999). The consequence of high prices is the reduced availability of milk products for vulnerable groups (Phelan 1994). These are children and people of low income. On the other hand the milk deficit calls for imports of milk products thus leading to a considerable drain on finances. von Massow (1984) drew attention to the increase in the volumes and values of dairy imports into Sub-Saharan Africa even though these countries faced a serious shortage of foreign exchange. Dairy imports made up about half the total milk consumption in West and central Africa (Von Massow, 1989), increasing throughout the 1970s and early 1980s, at an annual growth rate of 10% or more. Consequently, there are sustained efforts to develop domestic milk production in Sub-Saharan Africa (Walshe *et al*, 1991).

Formal research on dairy cattle started in Cameroon in the early 1970's (Tchoumboue and Jousset, 1982) on imported and local cattle. However, there is no comprehensive report available providing information on the key aspects of the research done on this topic in Cameroon to this day. In Sub-Saharan countries, because of inadequate available literature, there is always a risk of duplicating research and therefore wasting time and resources. There is also a need for information to be gathered on the subject and made available to policy makers. Consequently, this paper reviews and discusses work carried out in Cameroon in relation to dairying, suggesting ways to improving the sector and proposing lines for subsequent research.

2.3. Sites of dairy cattle production in Cameroon

The Republic of Cameroon is located in Central Africa and ranges from the equatorial forest to the Sahelian zone in Lake Tchad with a total land area of 475 440 km^2 and a human population of 14.693 million (FAO, 1999). The population is expected to reach 20.5 million in 2010 (Njoya *et al*, 1999). It is administratively divided into 10 regions covering five agro ecological zones. The cattle population stands at 6 million heads. Over 90% of the estimated cattle number is to be found in four regions, the Far North, the North, the Adamaoua and the North West Province (Kameni *et al*, 1999). The two regions that have been particularly associated with dairy production in Cameroon are as follows:

- The Adamaoua Plateau is situated at 1100 m above sea level. Weather conditions have been reported by Pamo and Yonkeu (1986). The climate is tropical, usually described as sudano-guinean, with a characteristic unimodal rainfall pattern. Two major seasons are prevalent, the wet season which runs from April (mean precipitations of 128.8 mm) to October (107.2 mm) and the dry season from November to March. The maximum monthly rainfall ever recorded was 325.6 mm and occurred in July. Total annual precipitation ranges from 1392 to 1982 mm per year. Mean relative humidity and temperature are 67.3% and 22.0 ^{o}C, respectively. Minimum and maximum temperatures are 10 and 34 ^{o}C, respectively. The hottest months are from November to January. Frost is rare on the highlands. Natural vegetation is woody savannah. It is a sudano-guinean type which is interspersed with *Daniellia* and *Lophira* spp trees. Major grasses have been described by Piot and Rippstein (1975) with predominant species being *Hyparrhenia* and *Panicum* spp.The principal improved pastures developed on station are *Brachiaria* and *Stylosanthes* spp.

- The Western Highlands, another dairy producing region, is located in the mid and high altitude zone of the country which lies between latitudes 5°20' and 7° North and longitude 9°40' and 11°10' East of the Equator. The surface area of the Region is 17,910 km^2 covering 1/6 of the country's land area. Altitudes range from 300 to 3000 m above sea level. The climate is marked by a dry season from November to mid March and a rainy season from mid March to October. Rainfall ranges between 1300-3000 mm with a mean of 2000 mm. Minimum and maximum temperatures have means of 15.50°C and 24.5°C, respectively; although temperatures can go above 30°C. There are three types of soils: volcanic, hydromorphic and ferralitic. The human population is estimated at 1.82 million inhabitants, being one of the highest population densities in the country, with at least 79 inhabitants per km^2 and a population growth rate of 3.1% (Winrock International, 1992). The agricultural population is estimated at 72% with 160,025 farm families. Agricultural products from low to medium altitude include: oil palm, cocoa, Robusta coffee, fruit trees, cocoyam, maize, small livestock, rice, and groundnuts. The high altitude (above 1400m) products include: solanum potato, Arabica coffee, vegetable and small and large ruminants (PNVRA, 2002).The region is the third major cattle producing area (500,000 cattle) after the North and the East. The main vegetation is Savannah. Pastures are dominant with *Sporobolus africanus*. But the following species can be encountered: *Pennisetum clandestinum* and *Pennisetum purpureum*, *Loudetia*, *Hyparrhenia*, *Urelytrum fasciculatun*, *Panicum phramitoides*, *Paspalum arbiculare*. Some improved species have also been introduced such as *Brachiaria* spp, *Trypsacum laxum*, *Stylosanthes* spp and tree legumes (Merlin *et al*, 1986; Njoya *et al*, 1999). The Western Highland of Cameroon is an area free of Tse Tse fly.

2.4. Traditional dairy production

In Africa, pastoralists derive up to 75% of their food needs from milk (Galvin, 1985). These pastoralists own about 50% of Africa's livestock (de Leeuw *et al*, 1995). In Cameroon, they own most of the cattle population. According to Kameni *et al* (1994), most of the available cow's milk in Cameroon is produced by the Fulani cattle men. In the Fulani tribe, cattle production is the main activity. Their life revolves around this activity and most of their income is derived from it. Crop production is marginal and is carried out by occasional labour. The cattle men practice a pastoralist type of management whereby cattle are held in the vicinity of the village or urban area during the wet season, and then taken to lower pastures during the hot months in search of better grazing (Douffissa, 1988 and 1993). In this traditional system, milk is considered as a by-product of beef production using breeds such as the Gudali, Red Fulani and White Fulani (*Bos indicus*). More than 90% of calvings occur during the rainy season (Njoya *et al*, 1999). Milk off take starts from 1 to 3 months post-calving. Calves are usually weaned at 10.5 months. A number of lactating animals are left on the camping area while the rest of the herd is taken for grazing. Milking is all done by hand and any milk not required by the owners is either boiled and sold as liquid milk or allowed to sour naturally to provide a base for a sorghum or maize porridge (Kameni *et al*, 1999). The milk can also be used for exchange for grain. When cattle herds reside around urban centres, they represent the major, perhaps only, source of fresh milk for urban dwellers. When cattle herds reside in remote areas, only a very limited amount of milk might occasionally be sold for cash because the camping areas are usually far away from urban centres and schools. So a major constraint on the supply of milk to urban populations is the effective marketing of the supplies of milk potentially available from pastoral herds. An added complication is that the demand for milk in the urban centres is greater in the dry season than in the wet season. However, in the dry season with cows being on transhumance, pastoralists are unable to take advantage of this increased demand while in the wet season, when cattle herds may be adjacent to urban centres, demand for milk is low and prices are depressed. The opportunity to capitalize on the demand for milk, coupled to the need to promote more productive dairy systems, has led to the importation of European type dairy cattle.

2.5. Exotic dairy cows in Cameroon

The first exotic dairy cattle were imported into Cameroon in the 1930s (Tambi, 1991) by expatriates. They were of the German Brown breed (Atekwana and Maximuangu, 1981). At the end of the Second World War, these cattle were replaced with Holstein Friesian cattle and an Austrian breed (Pinzgauer) in Buea. At the same time, the Montbéliard breed was introduced in Dschang and Jakiri for crossbreeding with local cattle. In 1964, a dairy experimental station was set up at Bambui (Njwe, 1984) and in 1967 Brown Swiss heifers were imported for crossbreeding with N'Dama cattle. Montbéliard semen was imported in 1975 for crossbreeding with Gudali (*Bos indicus*) females in the northern part of the country. Immediately preceding this, the Heifer Project International (HPI) signed an agreement with the government and the importation by HPI of Jersey cattle, Holstein Friesian cattle and semen started and continues to the present time (HPI, 1999). This same organisation has trained dairy farmers to practice a zero grazing system with Holstein Friesian cows imported from Ireland since 1994. Importations of exotic cattle resulted in the development of more specialist systems of dairying.

2.5.1. Semi-intensive system and crop and livestock integration

These systems of dairying use crossbred cattle with improved pasture grazing and supplements such as rice bran, palm kernel cake, wheat bran, and soya beans, all in small amounts. Fencing is common as is rotational grazing. Animals often make use of farm residues such as maize stovers, ground nut and bean haulms, rice straw, and banana forage. They are also supplemented with agro-industrial by products such as cottonseed cake, brewers grains and palm kernel cake and tree legumes such as *Leucaena* spp and other legumes (*Stylosanthes* spp, *Desmodium* spp). In the Western highlands, such systems are practiced by the Tikar (native) population (Njoya *et al*, 1999).

2.5.2. Intensive system of livestock production

Intensive systems involve on the one hand a few modern commercial farms; on the other hand, the cut and carry system where animals are kept in stables and supplemented with concentrate. It is these systems which use purebred high yielding dairy cows (HPI, 1999). Small scale farmers suffer however from a very heavy work load because of the lack of machinery. Efficient ways of management need to be developed in order to lighten this burden.

2.6. Productivity of breeds used for milk production

Nearly all milk production studies done in the country have been geared towards cattle which supply the majority of milk. The common traditional breeds involved in dairying are the *Bos indicus* Gudali, Red Fulani and White Fulani. Their production levels are indicated in Table II.1.

Table II.1: Summary of breed performance of animals used for milk production in Cameroon

Breed	Birth weight, (kg)	Daily gain from 13 to 41 weeks, (kg)	Age at 1st Calving, (days)	calving rates,%	Calving interval, (days)	Lactation length, (days)	Number of inseminations per conception	Milk yield per day of lactation, (kg)	Milk yield (kg)	Mortality from birth to 36months,%
Gudali(G)	22.5[1]	0.35[1]	1440	75	511	140			373	3.5
Red Fulani(RF)	21.5[1]	0.43[1]		76.9[2]		114[2]		2.4[1]	513[2] 295[1]	4.7[3]
White Fulani(WF)	22.3[1]	0.27[1]		76.1	444	175		2.8[1]	536 465[1]	4.6
Jersey(J)	16.8[1]	0.39[1]	924	79.5	419	315		8[1]	2681	8.9 to 26
Boran(B)			600[5]				2[5]		315[5]	
Holstein(H)	32.7[1]	0.44[1]	964	75.4	472	329	2.4[5]	11.5[1]	3202[1] 3471[2] 4750[5]	12.7 to 38
HXG(F1)			780	78.9	399	282			1575	6.3 to 20
HXRF(f1)			927	87.5	403	221			1551	5.8
JXWF(F1)			1077	78.8	382	189			1011	5.6 to11.5
MXG(F1)			1140[4]	82[4]	399[4]	258[4]			1380[4]	44[4]
M=Montbéliard										

N.B. superscripts relate to references
[1]IEMVT (1975/76); [2]IRZ(1982,1983,1984,1985); [3] Mbah (1984) and Mbah et al(1987); [4]Tawah and Mbah (1989); [5]HPI(1999);

Tawah and Rege (1996) reviewed information on White Fulani cattle related to the breed's physical characters and production parameters. They described its distribution and husbandry practices and concluded that the breed is economically important for several communities in West and Central Africa. Although the population size of the breed is large, crossbreeding with exotic and local breeds poses a long-term threat to this breed. Abassa *et al* (1993), then Bayemi (1999), investigated growth performance records of Gudali cattle. The latter developed models related to the growth of calves and heifers as a help to selection. The Red Fulani breed is found in many countries of West and Central Africa; Nigeria, Chad, Cameroon, Niger and the Central African Republic. They are extremely hardy and adapt to a wide range of conditions particularly to arid zones (Maule, 1990). These local breeds have been crossed with European *Bos taurus* breeds, including the Holstein Friesian, Jersey and Montbeliard (Mbah *et al*, 1987; Tawah and Mbah 1989; Mbah *et al*, 1991; Tawah *et al*, (1999a).

Tawah *et al* (1998) studied the fixed effects of genotype, parity, age at calving, season and year of birth of cows on lactation and reproductive performance. Traits analysed were lactation milk yield, lactation duration, annual milk yield, calving interval, dry period and age at first calving. They found as expected, that in Cameroon, Holstein cows produced more milk than any other breed; exotic or local. Holstein F1 crosses were also better than any other crosses in the same trait. The season of birth of cow also significantly affected the age at first calving. This means that female calves born in times of hardship (eg: dry season), took much longer to take in a calf. Tawah *et al*, (1999b) also studied the genotype and environmental factors of crossbreeding the local Gudali zebu cows with either Montbeliard or Holstein bulls. Their study confirmed reports that F1 crosses are superior to their backcrosses in milk production in harsh tropics. The results further revealed that Holstein x Gudali F1 cows were better than Montbeliard x Gudali F1 in milk production and reproductive performance. The performance of the F2 was lower than F1 in milk production and age at first calving. The authors recommended that Montbeliard x Gudali crosses be used for dairy-beef production systems because of their dual purpose nature while Holstein x Gudali crosses may be better suited for moderately intensive dairy production systems on the Cameroon Highlands and similar environments. Kamga *et al* (2001) working with Holstein, Jersey and their crosses with Gudali confirmed the suitability of Holstein x Gudali crosses for milk production in Cameroon.

2.7. Domestic milk production and demand

In Cameroon, the livestock sector represents 16% of the agricultural production in terms of Gross Domestic Production (MINPAT, 1986) and is dominated by large ruminants. The country has 6 million cattle with 4% milking cows (FAO, 1970-1999). The total number of cattle has been consistently increasing for over 30 years.

The increase in number of lactating cows in the 1990's may have been due to the new surge towards high yielding imported cows to increase domestic production. Annual per capita of milk production in Cameroon was estimated at 5.1kg (MINPAT, 1986) while consumption was estimated at 10kg / person / year by von Masow (1984). Total domestic production of milk was 50.000 tonnes (Tambi, 1991). In 1999, per capita production stood at 12.8kg while per capita consumption was 15.3kg in 1998 (calculated from FAO, 2000). In fact milk production in the country has substantially increased (from 48 000 tonnes to 184,000 tonnes). This jump occurred because of the policy carried out by NGO's aimed at importing and incouraging the use of European dairy breeds in the 1980's. However, this increase is not fully reflected in the quoted figures as population has increased over this period from 10 to 14.7 million inhabitants. However, the production is far from satisfying local demand for milk and milk products. Since the devaluation of the CFA Franc by 100% in 1994, the price of imported milk and milk products has more than doubled. Teuscher *et al*, (1992) estimated the level of imports of milk and milk products was 11480 tonnes, which represented about 50% of the adult per capita consumption. The low per capita consumption in subsequent years (less than half of Africa's) reflects the limits on imports of dairy products in the country, standing only at 23% of total per capita consumption. Consequently, local milk can compete with imported products. In the past, the availability of cheap products in international markets supported low consumer prices in the country. Approximately 50% of the population are urban dwellers. Figure 2.1. shows that although urban population is rapidly increasing, imports of milk have slowed down.

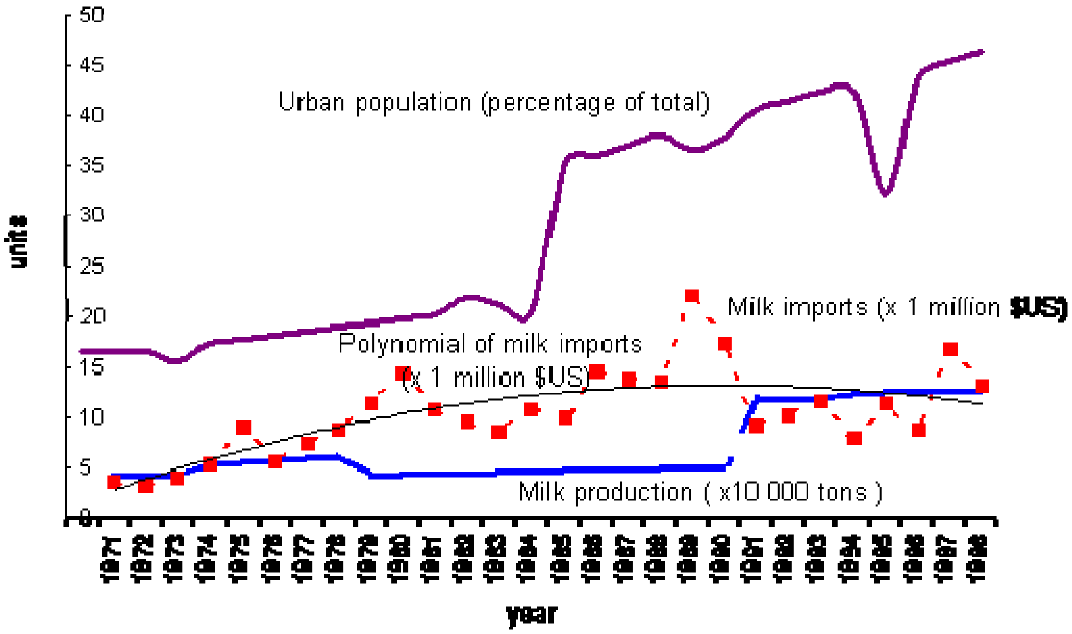

Figure 2.1. Dairy product imports relative to urban population (urban population relative to total population of the country)

This trend was confirmed by ILCA (1993). On the positive side, the present situation creates an extraordinary opportunity for dairy development. Already, many small peri-urban farmers are selling fresh milk at 200F perkg (0.3 $US). This is the retail price recommended by Pingpoh (1985) who suggested that in order to make the dairy business profitable, the price of milk be increased by over 50%, from 140 CFA (1/5 $US) to 214 CFA /kg. This reality has led some peri-urban farmers to use purebred Holstein Friesan cows. In order to maximize profit, these animals were imported for commercial production in increasing numbers over the last five years. For a sound and progressive development of the sector, dairy cooperative societies have been formed (e.g. the "Projet laitier" in Ngaoundéré, Adamaoua in the Northern part of the country and TADU dairy cooperative and Bamenda Dairy Cooperative Society in the North West). A private dairy processing company, SOTRAMILK, ensures the purchase of their liquid milk.

2.8. The urban demand for milk

A study conducted by Vabi and Tambi (1995) revealed that urban dwellers had a high preference for fresh milk with a mean household consumption of 3kg for the high-income households, 3kg for the low-, and 2kg for the medium-income households. Although high-income households spent more money on fresh milk compared to the medium- and low-income households, the proportion of income spent on fresh milk was lowest for the high, followed by medium- and low-income households. The authors suggested the need to organize home-based education programmes on nutrition as a strategy for boosting the consumption of dairy products among low-income households. It is therefore surprising that Tambi (1998) classified milk and milk products in Cameroon as relative luxuries and mentioned that they were considered as substitute for meat. Meanwhile low income households spent a high proportion of their money on these products.

2.9. Constraints to milk production in Cameroon

Traditional dairy management, though sustainable for centuries, does not supply enough milk to meet the ever growing demand. Improvement in milk production in Cameroon is possible thanks to the introduction of European type dairy breeds. Though adapting to the environment, these exotic breeds and their crossbreeds are found to be susceptible to the challenging Cameroonian environment. Constraints to dairy production are listed in Table II.2.

Table II.2. Tabulated constraints to dairy cattle production in Cameroon

	Constraints	Source
Nutrition	1. Traditional grasses are of low nutritive value and demand adequate supplementation; in February, native *Sporobolus africanus* only contains 4.5% crude protein on a dry matter basis.	Njoya *et al*, 1999
	2. There is inadequate pasture management. Some areas are densely populated, leading to insufficient grazing land. Consequently many dairy farmers endeavour to cultivate grass.	
Breeding and management	1. Unavailability of good dairy breeds. Many people wish to get involved in dairy business but either they do not find dairy heifers for purchase or more often they are very expensive to be bought on cash. Some NGOs give loans to farmers in this line, to be paid in kind with a heifer or a bull of the same breeds 3 years later.	HPI, 1999
	2. There is a long calving to conception period with a mean of 185 plus or minus 105 days. Moreover, the calving interval is long meaning that there is a great need of increasing reproductive performance on farms.	Njoya *et al*, 1999
	3. In improved systems (semi intensive and intensive) there are problems with heat detection and low artificial insemination success rates.	

	Table II.2. Tabulated constraints to dairy cattle in Cameroon (continued)	
Health	1. Ticks and tick-borne diseases are an obstacle to the introduction of exotic dairy breeds. They show a high susceptibility to Babesiosis, cowdriosis and dermatophilosis. Attempts to control ticks with acaricides have been proposed.	Mbah, 1982 a,b Merlin *et al*, 1986 Merlin, 1987 Merlin *et al*, 1987 Bayemi 1991 Ndi *et al*, 1991 Douffissa 1993 Staschurski 1993 Ndi *et al*, 1998
	2. Brucellosis	Martrenchar *et al*, 1995
	3. Haemorrhagic septicaemia	Martrenchar and Njanpop 1994
	4. Gastrointestinal parasites: *Toxocara, Strongyloides, Coccidia Trichuris, Moniezia, Fasciola* and paramphistomes infest dairy cattle. Deworming with anthelmintic was recommended	Chollet *et al*, 1994
	5. Foot and mouth disease commonly present	Ekue *et al*, 1990 Bronsvoort *et al*, 2002
	6. There are inadequate veterinary inputs by dairy farmers. Most of them keep their animals indoors, because of the fear of high tick load and worm loads. Exotic breeds though highly performing are very susceptible to parasites and heat stress. Therefore in Table II.1., they show very high mortality rates.	Mbanya *et al*, 1995
	7. Because of high costs of conventional veterinary medicine. Many farmers use ethno veterinary medicine	Nfi *et al*, 2001

	Table II.2. Tabulated constraints to dairy cattle in Cameroon (continued)	
Processing **Marketing** **Consumption**	1. Limited quantity of milk for processing and consumption in urban areas	HPI, 1999
	2. Farmers who are a long way from urban centres cannot easily sell their milk. Consequently, cows are milked once day to sustain the family needs. At farm level, there are no cooling or storage facilities for fresh milk as well as a lack of processing facilities and technical know-how. In peri urban areas there is no collection of evening milk for processing. Therefore, the milk is mainly consumed by family and fed to pet animals and calves.	HPI, 1999 Kameni *et al*, 1999

2.10. Milk processing

Traditionally, milking was found to be carried out once a day in the morning, mainly by women and children, often with very little hygiene and sanitation. The calf is allowed to suckle in order to induce milk let down in the zebu cows. The milk is low in microbial quality. Therefore it lasts for 3 to 4 hours at room temperature (ambient temperatures are 30 to 35 ^{o}C) in the northern part of the country. In the Western Highlands where temperatures are moderate (18 to 22 ^{o}C) the shelf life of milk is slightly longer. Traditional processing is carried out by women. Various locally made milk products can be seen in markets and shops in urban areas of Cameroon. Kameni *et al*, (1999) investigated milk products found in Cameroon and classified them as those from traditional or modern processing methods. Dairy plants make sweetened yoghurt, set yoghurt (natural), stirred fruit yoghurt, stirred plain yoghurt, and cheese. The following products are found at household level: Pendidam (fermented milk), Kindirmu (set yoghurt), heat treated milk, Lebol (butter), Nebam (butter oil) and sour milk.

Milk is pasteurized by processing plants - Sotramilk and Projet Laitier. Another dairy plant is being built at Tadu near Kumbo. These plants are not running at full capacity but ensure that seasonal volumes of surplus milk are efficiently utilized. Imele *et al* (1999) determined the composition of milk from White Fulani cows as: butter fat (3.89±0.17%), protein (3.52±0.21%), total solids (12.69±0.43%), solids-not-fat (8.79±0.44%). It might be better for the same work to be carried out with other breeds.

Kameni *et al* (2002) worked on suitable temperature and time for proper pasteurization of milk under local conditions in Cameroon. They recommended that at household level, milk should be heated to at least 74 degrees Celsius for more that 10 minutes to ensure safe milk supply in the country. Kamga *et al* (1999), attempted to determine the time of maturation of cream for obtaining butter of higher quality and good yield. They suggested that cream should be matured for not more than 30 hours by farmers who have no refrigeration facilities (this period ensures better quality and yield of butter) and 7 hours by those who intend to use refrigerators. Lower temperatures led to earlier maturation of cream. A number of other studies dealt with cheese. Kameni *et al* (1994 and 1998)) studied the production of cheese in Cameroon. Studies of Bafut cheese showed that a typical Bafut cheese is hard, cylindrical and of 2kg in weight and covered with a dry, hard rind formed by moisture loss during maturation. Furthermore, Kameni and Imele (1997) demonstrated that heat treating raw milk increased wet yield and recovery of total solids of local Edam-type cheese. Milk was heated to experimental temperatures up to 90 degrees Celsius and immediately cooled to 32 degrees Celsius. Milk gel setting time increased from 30mn to 165mn with corresponding experimental temperatures of 32 and 90 degrees Celsius respectively. These results imply the need to understand detailed local processing method for cheese making in order to give proper recommendations to farmers. If the milk is not heated, the resulting cheese might be high in microbial contents. In contrast if the milk is heated above 70 degrees Celsius, coagulation time might be too long.

Technologies for local milk processing at household level might be of great importance for remote areas where marketing of liquid milk is a problem. Milk can be transformed and the products transported to urban areas. However, stress should be put on hygiene for the products to be properly accepted.

2.11. Marketing of milk and meat

Milk marketing is primarily ensured by the informal sector. Middle men are rare as farmers directly take their milk to the market. Rather there are many small scale processing units which collect milk for processing into yoghurt and traditional sour milk. In the dry season, market demand in Cameroon for milk products is very high but milk is scarce because cattle are managed in a transhumance system. Even when milk is available, the lack of refrigeration at farm level forces producers to make and market their products every day. The marketing system is mainly informal. In Garoua, there are large herds of cattle and a lot of milk in the rainy season. Women carry the milk products on their heads and walk around town to retail them. In Maroua where milk output is low, dairy products are expensive because of traditional form of management, and a special site has been provided for the sale of milk in the main market. In Bamenda, milk collection is done in main axes with refrigerated vans by Sotramilk. This is a dairy plant collecting in January 100 litres per day and in September-October (peak), 500 liters per day. They use blend and reconstituted milk to make their products (Mbanya *et al*, 1995). In order to ensure better marketing for their milk, farmers constitute themselves in cooperatives. Tambi and Vabi (1994), surveying one of the cooperative dairy farmers, said that the financial responsibility of the household head (gender), input cost, and price significantly influence market supply. They stated however that price is relatively inflexible to changes in market supply.

Meat consumption in Cameroon was of 217,000 metric tonnes (MT) in 1998 and 237 MT in 2003 (FAO, 2006). Ninety-eight percent of this was from domestic production while the remaining 2% was imported. Beef is the most important meat consumed, followed by mutton and goat meat, pork and poultry in that order. Other meats, including offals and game meat, are also important and account for one-fifth of total meat consumption. Total meat consumption increased by 80% (4.4% per year) from 1980 to 1998. The largest absolute increase of more than 40,000MT was in beef consumption. Poultry meat consumption increased by more than three times while mutton and goat meat consumption more than doubled during the same time period. Fish is a relative necessity in Cameroon and is often substituted for beef and chicken by households whose profiles include being of low income levels, having large household sizes, are of middle age and are less educated. Whereas chicken and pork substitute each other, they are each complementary to beef. Profiles for households most likely to increase their purchases of chicken include being of high income levels and are public sector employed (Tambi, 2001). It is quite likely that the production of meat increases as the government of Cameroon has reduced the importation of frozen chicken by 5000 tons per annum with the possibility of definitely suspending importation if local producers can satisfy local demand (Fonzenyuy and Suika, 2005). This pushes prices up and encourages local production.

2.12. The way ahead

Favourable factors for improved milk production were already outlined by Makek (1980). The Cameroon government has an ambitious plan to substantially improve livestock products by the year 2005 (MINEPIA, 2002). Moreover, the republic of Cameroon owns a large cattle population. Traditionally, livestock farming techniques have remained largely as they have been for centuries (Pradère, 1982). Although it seems difficult to bring about much improvement in the pastoral system, it is still necessary to assist these farmers particularly in the area of health control and milk hygiene, so that the products marketed will be safe for the public. Many regions still depend on them for the supply of milk. The Cameroonian climate is appropriate for good pasture development. Some areas, especially in the Western Highlands, are free of tse tse fly and are therefore very suitable for dairy development. Although the performance of high producing breeds imported to Cameroon is lower than their genetic potential, it is still far above that of local breeds. These animals are therefore suitable for milk production in the country.

Enough work has already been done on crossbreeding local with exotic dairy breeds as cited in this thesis. These studies have recommended upon the use of F1 progeny. But because of the lack of a stabilised breed, there is a dependence on imported bulls or semen and artificial insemination. This leads to the lengthening of the calving interval in times of unavailability of imported semen and artificial insemination technicians. The dependence on imported semen has the advantage of farmers benefiting from genetic progress made in developed countries. However, as in the present situation, unplanned crossbreeding may lead to the disappearance of local breeds. Therefore, there is a need for research to tackle the preservation of local cattle genetic resources in the country, by characterising, selecting and breeding local purebreds for meat production in order to lead to dual purpose F1.

Little work has been done on nutrition using available local material. This is another area where research in needed, particularly in adapting research done in similar environments in other countries to Cameroonian conditions. The existence of dairy plants confirms the fact that there is a market for dairy products in the country. But the price paid to farmers for fresh milk could be better if farmers were efficiently organized in sound cooperatives instead of scattered small groups.

Much research is needed to study efficient methods of transferring research results to farmers. Some extension work on dairying has been accomplished by non-governmental organizations which offer a credit scheme to farmers to own dairy cattle, but the number of in-calf heifers is still very limited. There is an urgent need for the government to assist dairy farmers in this line. In fact, there seems to be serious obstacles to dairy development unless the government organizes and supports the sector at least until the World Trade Organization convinces the European Union and the United States among other countries to completely stop subsidizing agriculture. Such a limited involvement of the state has helped small scale dairying to be successful in countries such as India. This partial support will help small farmers to develop production and be in the long term independent.

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CHAPTER 3

3. Surveys

3.1. Participatory rural appraisal of dairy farms in the North West Province of Cameroon

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3.1.1. Abstract

A Participatory rural appraisal (PRA) was conducted in dairy farms of the North West Region of Cameroon. The aim of the PRA was to have a better understanding of the prevailing dairy systems, identify problems, and set priorities for research and development that can contribute to improved systems of production. A multidisciplinary team of researchers and extension agents was constituted. It was made up of scientists of the following fields: cattle management, forage science, agro economy, veterinary, dairy technology, nutrition and extension. The research team visited farmers' groups and divided itself into subgroups for farm and village walks during which direct observations were also noted. The extension agent of the locality, key informant, gave additional information overlooked by farmers. Interviews were also carried out with other stakeholders of the dairy sector. The research team met the day following the visit to agree on a common report. Results show that five small scale dairy production systems are found in the region: transhumance, improved extensive, semi intensive, zero grazing and peri-urban. Agriculture is well integrated to dairying. Main constraints include in order of importance: poor marketing opportunities and long distances to market, limited grazing land and poor supplementation of cattle, limited health control, inadequate knowledge in processing, conservation and storage of milk, poor reproductive management and prolonged calving interval, lack of water in the dry season, poor housing, poor organization of group, limited number of dairy cows and poor record keeping. In market oriented farms, reproduction and feeding were the most important constraints. Main factors influencing dairy production are: milk collection, fresh milk price, consumer demand, genotype and management. These results suggest that much can be done to improve production by extending improved packages to dairy farmers.

Key words: Cameroon, cattle, dairy systems, milk, participatory rural appraisal

3.1.2. Introduction

Cameroon human population is growing at a rate of 5% per year (MINEPIA, 2002). There is unceasing worry to feed this population. Annual per capita of milk production in Cameroon was estimated at 5.1kg (MINPAT, 1986) while consumption was estimated at 10kg / person / year by Von Masow (1984). Total domestic production of milk was 50,000 tonnes (Tambi, 1991). In 1999, per capita production stood at 12.8kg while per capita consumption was 15.3kg in 1998 (calculated from FAO, 2000). Milk production in the country has substantially increased in the last 15 years from 48,000 tonnes to 184,000 tonnes. However, the production is far from satisfying local demand for milk and milk products. This gap in domestic demand is being over the years covered by large imports. Teuscher *et al* (1992) estimated that the level of imports of milk and milk products was 11480 tonnes, which represented about 50% of the adult per capita consumption. However, due to the devaluation of the CFA Franc currency used in the country by 100% in 1994, per capita consumption in subsequent years dropped to less than half of Africa's which is 34kg/person/year (294kg/person/year in Europe) reflecting the limits in imports of dairy products in the country, standing only at 23% of total per capita consumption. Imported products are expensive for common Cameroonians. Consequently, products from local milk can more efficiently compete with imported ones. This paves the way for a huge development in local milk production. This development will be effective if there is a detailed knowledge of the dairy production environment in the country. Interventions will be easily measured, felt and seen if they were applied in selected farms and economic effect of interventions monitored.

More than fifteen years ago (Douffissa, 1988), three cattle systems were defined in Cameroon: traditional, semi intensive and intensive. However, the economical, political and environmental conditions have drastically changed in the country. There is limited knowledge of current milk production systems in Cameroon. What are their constraints and limitations? What stakeholders and factors influence dairy production? What is the marketing channel? What perceptions have dairy farmers in this activity and what suggestions can be given to improve dairy production in the country? What is the economic reference point of selected farms that could be used for measuring results of subsequent interventions? The following research was conceived to attempt answers to the above questions.

3.1.3. Material and methods

3.1.3.1. Dairy cattle production regions in Cameroon

The Republic of Cameroon is located in Central Africa and ranges from the equatorial forest to the Sahelian zone in Lake Tchad with a total land area of 475,440 km^2 and a human population of 14.693 million (FAO, 2000). The population is expected to reach 20.5 million in 2010 (Njoya *et al*, 1999). It is administratively divided into 10 regions covering five agro ecological zones. The cattle population stands at 6 million heads. Over 90% of the estimated cattle number is to be found in four regions, the Far North, the North, the Adamaoua and the North West Province (Kameni *et al*, 1999). The two regions that have been particularly associated with dairy production in Cameroon are the Adamaoua Plateau and the North West region. The study was carried out in this region.

3.1.3.2. Participatory rural appraisal (PRA)

The Participatory rural appraisal was used as a tool to identify constraints (Bandhari, 2003) and suggest interventions geared towards promoting the sustainable development of dairy production in the North West Region of the Western Highlands Cameroon.

3.1.3.3. Selection of study area

This site was chosen because it is the most appropriate environment for dairy improvement in the country. Not only it is free of Tse Tse fly, but the region is linked to the two major towns, Douala and Yaoundé by a good road network. Temperatures are the lowest in the country therefore suitable for high yielding breeds. Milk production in this area is government priority. A dairy technology laboratory has been set in the area to improve milk processing. Furthermore, the Heifer Project International has established its head quarters in the region to closely help farmers in dairy management. On the other hand, milk produced in the northern part of the country is mostly through pastoralists who are not very open to change in cattle management. The North West region is therefore very suitable for improvement in dairy production and was chosen consequently.

3.1.3.4. Research team and PRA method

A multidisciplinary research team was constituted with scientists of different fields as follows: a cattle and forage scientist, an agro economist, a dairy technologist, a veterinarian, an extension agent and various technicians. One researcher, a lady helped to establish links with women in communities were foreign men were not allowed to individually question women. Farmers were choosen on their willingness for long term cooperation with the research team and easy access. The team first decided on the site and farmers' group to be visited. Contact was established with the group through phone numbers or government 'zonal extension workers'. A date and time were arranged at the convenience of the farmers' group. Some food or local drinks were prepared to make the discussion free and informal. A PRA topical guideline was prepared as a semi-structured interview consisting of the following points: introduction on purpose of the meeting and visit; presentation of the team; presentation of individual farmers present; questions on cropping, cattle management, milk processing and marketing, labour, constraints and prioritization, other activities, expectations, other comments. Finally a dictation machine (tape recorder) was discretely used during group discussions to avoid writing down every piece of information. The questionnaire was translated in the very common pidgin language by a researcher, native of the area. It was pre-tested at one locality (Sabga) and readjusted for shortening the time taken for group discussions, order of questioning and few more questions were added. Sometimes there was a need to translate part of the discussion into/from local dialects. This was either done by a research team member or a member of the dairy group.

At arrival at the site the research team was welcomed by the extension agent who introduced it to the group. The team explained the purpose of the visit and initiated the discussion. The team sat in an indiscriminate manner, and mingled with farmers to create more confidence among both parties. Although a leader guided the discussion, any other scientist could intervene at any moment to ask for appropriate information that could have been overlooked. The zonal extension agent, key informant, also took part in the discussion. He gave additional information that the farmers were unable to provide. Care was taken to avoid people monopolizing the discussion because of their wealth status or leadership role.

The group discussion proper took place in one of the farmers' houses or in a common group house. It lasted a maximum of two hours. After the discussion a field visit to various farms was organized. In some cases the research team divided itself into sub groups of 2-3 people; in other instances the whole team visited farms. Much information was also gathered from questions asked to farmers during the village walk. Transects and direct observations were done during the field walk. Body maps were drawn by 36 farmers to diagnose health problems in two groups. Visits usually ended with a meal taken with farmers. However, there were further questions asked to the key informant to collect additional information or crosscheck farmers' answers. The visit lasted a day in each group. In some villages (Sabga, Jakiri, and Tadu) because of gender-separated way of life, women were interviewed from men in separate visits. A total of 137 farmers were individually interviewed representing about 25% of dairy farmers registered in 32 dairy groups and three dairy cooperatives. Interviews were also carried out with other stakeholders of the dairy sector such as Non-governmental Organizations, industries and government officers. The research team met the day following the visit to gather information and write a report.

Secondary data used in this work involved annual reports of IRZ (1984, 1985, 1986); results of previous surveys involving dairy production in the region (HPI, 1999; Kameni *et al*, 1999); current statistics from dairy cooperatives and non governmental organisations.

3.1.3.5. Data analysis of PRA information

As suggested by Pretty (1994), the validity of the data was ensured by: forming a research team with members having differences in scientific disciplines, ethnicity, age, religion and gender. Main points noted in a group were read to the participants at the end of gathering and corrected. During the research report writing, there was crosschecking of information collected by each member of the multidisciplinary team. The results were submitted to review in a scientific presentation to colleagues and to peer review. Results were subsequently compared to secondary data.

Three methods were used for constraints ranking: first, farmers agreed among themselves and a spokesman expressed the major constraint by order of importance. Where this agreement failed, farmers were asked to close their eyes and put their hands up when a constraint was listed. Eyes were closed to reduce influence from other farmers. The numbers of farmers voting for a particular constraint was subsequently counted. Lastly, Ashby's method (1986) was used to rank constraints in the whole region. Simple statistics were used to calculate percentages.

3.1.4. Results

3.1.4.1. Seasonal calendar of activities of dairy farmers

Farming activities of dairy farmers of the Western Highlands can be divided as indicated in Figure 3.1.1.

Activities such as milking, forage cut and carry for purebreds Holstein or Jersey, milk processing and marketing are permanent throughout the year, while farming and transhumance depend on the two seasons, wet and dry. These activities are similar for the whole region.

3.1.4.2. Cattle feeding

Much milk produced in the Western Highlands of Cameroon is from native cattle. These cattle are usually grazing native pastures of *Sporobolus africanus, Pennisetum purporeum* and *Melinis multiflora*. However, pastures have also been improved with planted grasses, legumes and multipurpose trees (MPT). These are for grasses: *Brachiaria spp, Trypsacum laxum, Kikuyu (Pennisetum clandestinum)*. Trees are being planted as live fences and are: *Caliandra spp*, *Leucaena leucocephala*, *Jacaranda spp* and *Acacia spp*. Cattle are also fed on by-products, waste food and fruits such as sugar cane leaves, potato leaves, guavas, ripe bananas, pumpkins and waste cooked corn (fufu). Crop residues include: corn stovers, banana pseudo stems and leaves, ground nuts and beans haulms.

The following ingredients are commonly used in supplementation: Maize, rice bran, wheat bran, palm kernel cake, cotton seed cake, whole soya beans, bone ash, limestone and table salt. The proportion of farmers using different feedstuffs in the peri-urban areas of Bamenda and Fundong is shown in Table III.1.1.

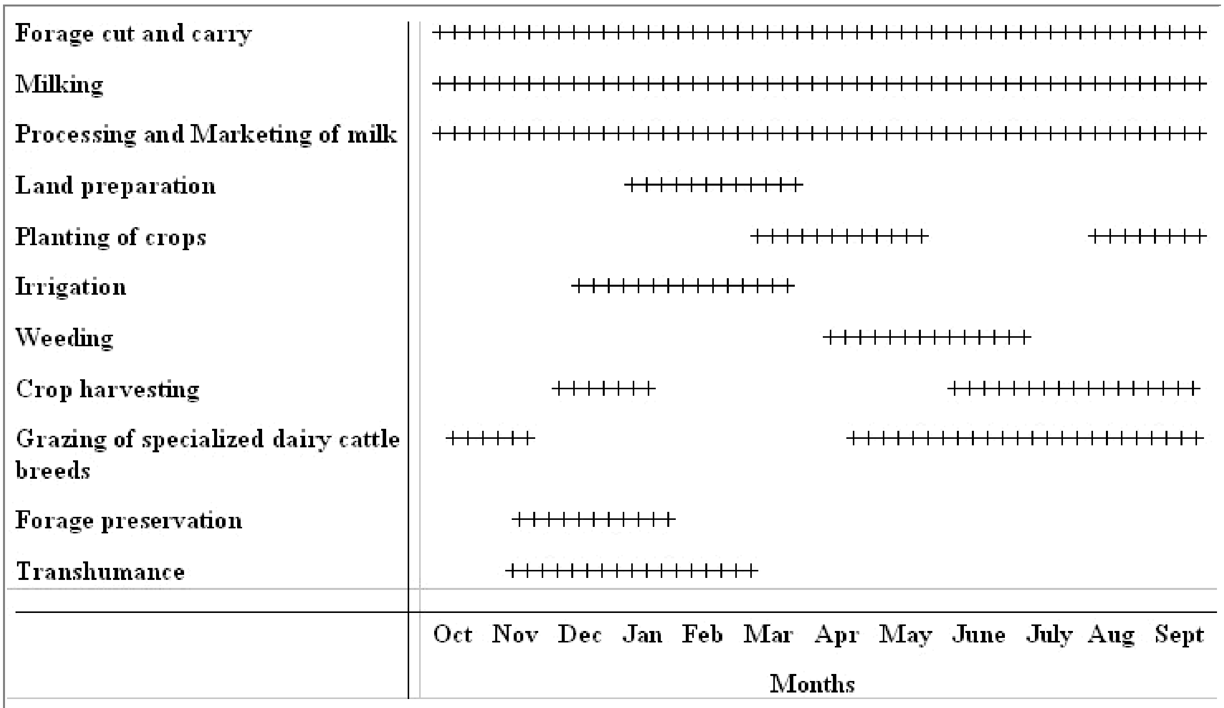

Figure 3.1.1. Farming activities carried out by dairy farmers of the Western Highlands of Cameroon

Table III.1.1. Proportion of farmers using different feedstuffs in homemade concentrates

Ingredient	**% of farmers using in feed mixture**	**Source of feed**
Maize	79.0	Purchase or farm harvested
Wheat bran	67.4	Purchased
Cotton seed cake	53.5	Purchased
Whole soya beans flour	48.8	Farm harvested
Rice bran	46.5	Purchased
Palm kernel cake	41.8	Purchased
Soya bran cake	13.9	Purchased

Principal energy providing ingredients are maize and wheat bran while protein mostly comes from cotton seed cake or whole soya bean flour. Traditional farmers use table salt as sole supplement to cattle in the areas of Sabga, Jakiri and Bamdzeng. Concentrate is fed to dairy cows during milking.

3.1.4.3. Cattle breeding

Traditional producers have been using for a long time natural mating from visually-selected bulls bought, exchanged or loaned from other farmers. With the aim of upgrading the traditional stock, artificial insemination (AI) is being used in Jakiri, Tadu and Bamdzeng. AI is also used in Holstein cows in Fundong (Meli and Mukweh), Nkwen and Santa. In the Bamenda surroundings where there is a high failure of AI, purebred Holstein bulls are used for natural mating. In Sabga and Jakiri, farmers use crossbred bulls for breeding therefore obtaining ¼ Holstein crosses in the progeny.

Dairy cows are bred as from two months post-partum. The calving interval lies between 12 and 18 months. Improved breeds reach active sexual maturity at 24 months while local breeds are sexually active as from 36 months of age.

3.1.4.4. Calf management

Calves from purebred dams are weaned at 4 months of age while in traditional herds weaning is between 7 and 12 months. Weaning is done by separating calves from cows for 3 weeks or by rubbing a mixture of rotten colostrum and dung in mother's udder, thus repulsing the calf. Calves from local breed suckle dams for one month before milking starts. Purebred calves are first given colostrum; then are bucket fed in elevated pens as from three days post-partum as follows: less than one month 5-6 litres of milk/calf/day; 1

to 2 months, 3-4 litres/calf/day; 2-3months, 2-3 litres/calf/day and 3-4 months, 1litre of milk/calf/day. Forage is introduced between 2 and 4 weeks of calving.

3.1.4.5. Milking

In traditional herds, cows to be milked are chosen with the following criteria: calmness and high milk production, older cows are preferred to young ones. In general milking is done in the morning between 6 and 8 am and in the evening between 4 and 6 pm. Purebred Holsteins are milked twice a day. In Tadu milking sometimes goes up to 3 times a day. Milking of local breeds is still done with poor hygiene consisting of few seconds suckling by calf to favour milk let down. Milking is then done with calf presence. Dairy farmers owning purebred Holstein clean the udder with warm water and rub it with Vaseline before and after milking. Milking is done manually and milk is collected in buckets after tying the cow's hind legs.

3.1.4.6. Cattle production

Breed production is summarized in Table III.1.2. The impact of pure Holstein Friesian is increasing in the region, particularly in peri-urban areas of Bamenda in Mezam and Fundong in Boyo (Figure 3.1.2). Many women are also involved in rearing this breed. Figure 3.1.3 indicates the quantity of milk collected by Sotramilk (see below). Much milk is produced in the rainy season when forage is abundant. Figure 3.1.4 shows that the sources of milk products in the country are either imported or locally produced.

Table III.1.2. Daily quantities of milk produced in the traditional system (lactation length 7 to 10 months)

Breed	**Dry season (maximum litres/cow/day)**	**Rainy season (maximum litres/cow/day)**
White Fulani	1	2
Red Fulani	2	4
Gudali	2	4
Brahman crosses	2	4
Holstein crosses	8	15
Holstein Friesian	-	25

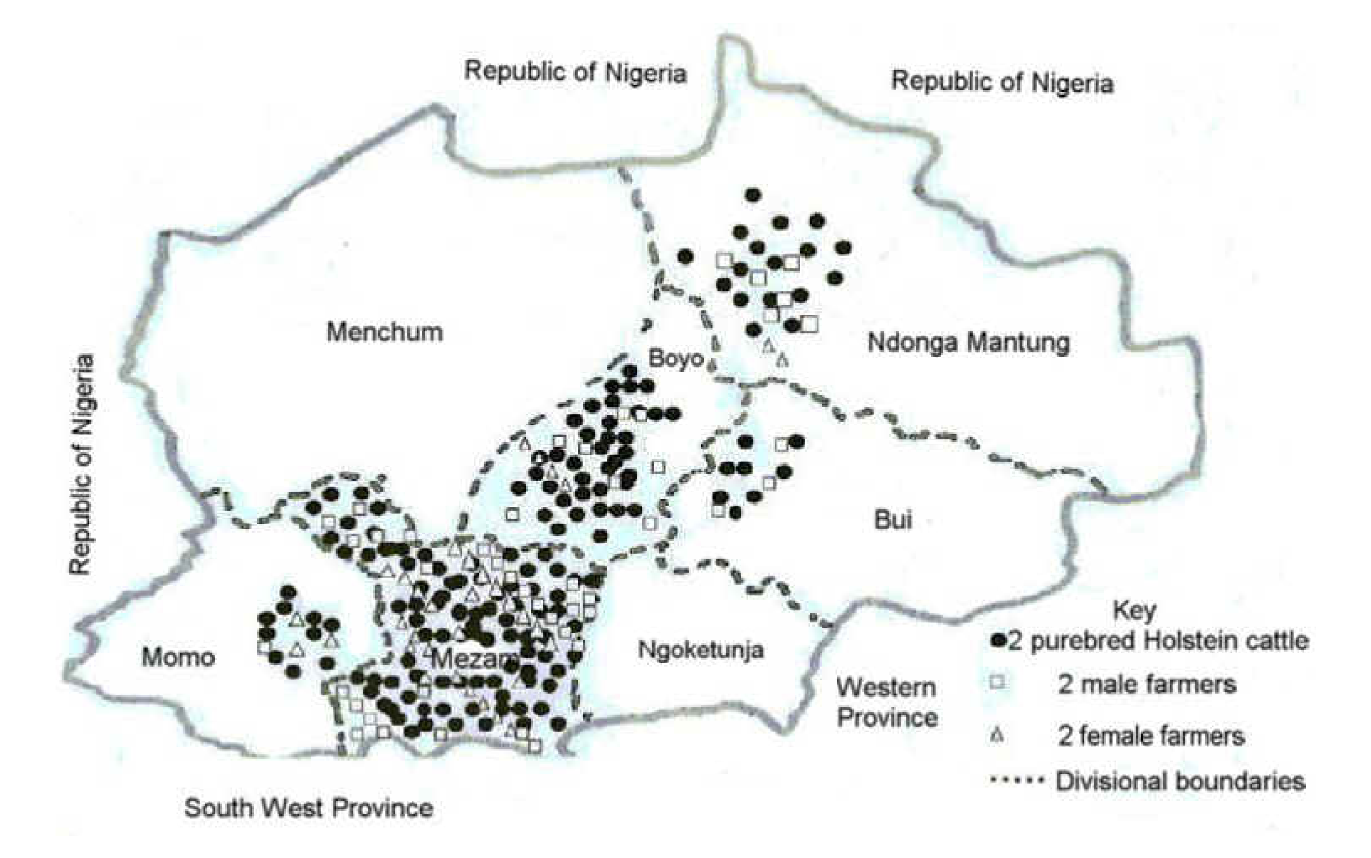

Figure 3.1.2. Regional distribution of Holstein Friesian cattle in the North West Region of Cameroon

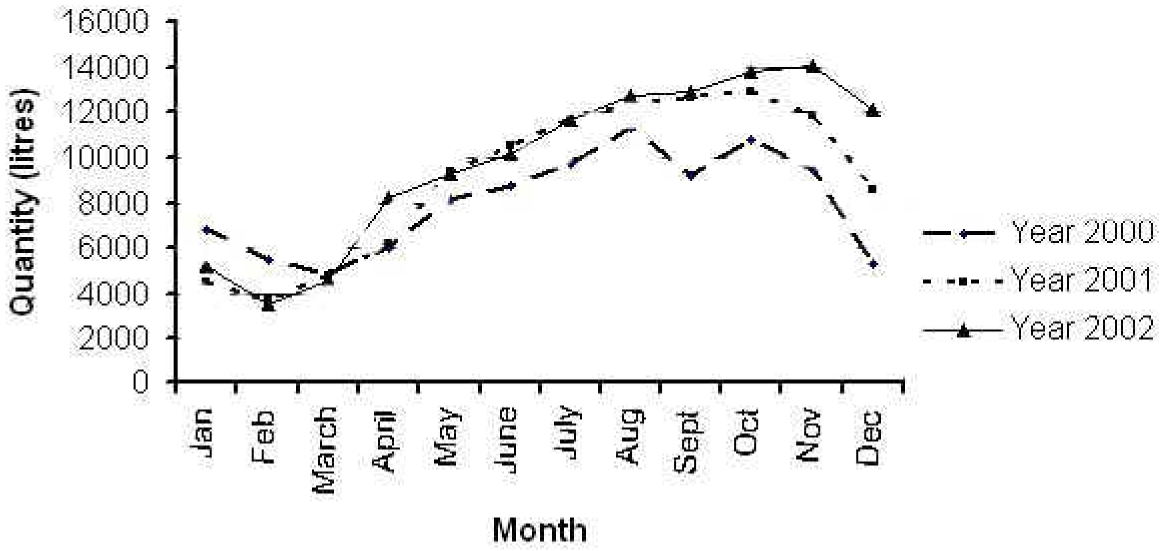

Figure 3.1.3. Monthly milk supply to SOTRAMILK

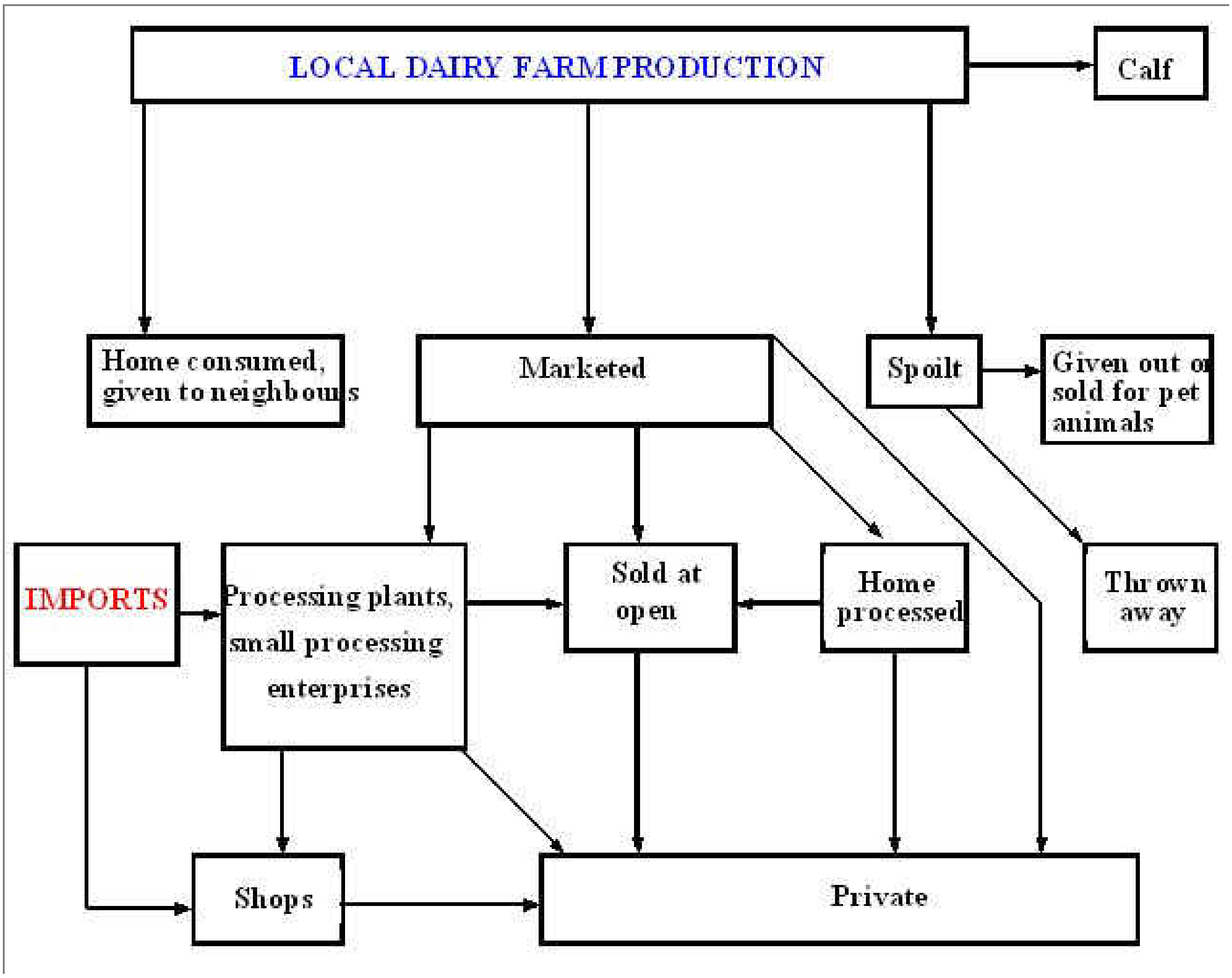

Figure 3.1.4. Milk marketing channels in Cameroon

Table III.1.3. Average cost of milk and milk products (1$ = 650FCFA; 1000FCFA = $ 1.5)

Dairy products made from milk	**Average cost in dry season, FCFA**	**Average cost in rainy season, FCFA**	**Average village price, FCFA**	**Average town price, FCFA**
Local products				
Liquid milk price per litre*	250	200	200	300
Pendidam (sour skimmed milk), price per litre	300	250	100	200
Kindirmu (sour whole milk), price per litre	500			
Butter	100 per 200ml	1500 per 900g	100 per 200ml	100
Butter	100 per 200ml	1500 per 900g	100 per200ml	100
Butter oil, price per litre	3500	3000	2000	2000
Yoghurt, price per litre	1500	1500		
Cheese, price perkg	6000	6000		
Imported available milk products or made from imported milk				
Sterilized milk can screamed	1000			
Power milk	1900 per 800g	1900 per 500g		
Butter	845 per 200g	500 per 200g		
Yoghurt	250 per 125ml	250 per 125ml		
Cheese, price perkg	10000	1000		
Concentrated, price perkg	1500	1500		

** SOTRAMILK buying from farmers at 160 per litre.*

Milk not taken by calves is either home consumed, spoilt or marketed. No cooperative collects milk. Milk and milk products are marketed either directly by producers or are collected by processing companies. In the peri-urban area of Bamenda, milk marketing is more formal through Sotramilk. In other areas, milk marketing is informal. Milk is either bought at the farm by individuals or farmers carry it to the market place. In this case the price is higher than what is offered by the processing plants. This pattern also happens in the northern part of the country with much activity where former processing plants closed up because of lack of sufficient milk supply. Costs of products are indicated in Table III.1.3.

Home processed products and milk sold in the open market are still much a part of the marketing channel. If better quality products are to be supplied to consumers, there is a need for methods on processing and hygiene to be extended to farmers. On average, 20 to 50% of milk is home consumed in places where marketing is a problem. In Meli (Fundong), sour milk (spoilt) is sold to dog owners. After milking, women and children can take up to 2 hours to get to the market place, and wait for up to 4 hours for the milk to be sold before going back to the homestead.

3.1.4.7. Housing and manure

In traditional management, cattle graze on a free-range system with nights spent in open pastures. In the peri-urban management, there are sleeping paddocks and sleeping sheds constructed with wood and the roof made of either zinc material or local grass. In the last system cows are milked in sheds cemented with concrete. In the zero grazing system, some farmers had very poor sheds letting mature cows eat grass from the roof, thus destroying it.

Manure is a very important activity in the cut and carry (zero grazing) farms and in peri-urban areas where gardening and agriculture are much rewarded. This manure is collected with spades and kept in pits before being dried, used or sold. There is little hazard from manure as the quantity is small.

3.1.4.8. Labour and gender

Generally, the whole family is involved in cattle caring. In the more pastoralist communities, adult men take cattle for grazing while women and children do the milking, processing and milk marketing. School children milk cows before going to school in the morning. The peak period for labour demand is the dry season (January to March) when the farming season starts. At this time, labour is hired to take cattle for transhumance at a cost of 15 000 FCFA per month. Labour is paid for farm preparation at 10000 to 20000 FCFA for a one eighth hectare farm or 600FCFA per man day. When men are married to many wives, at least one of them is in charge of farming and gardening. In the Fulani pastoralist communities, men own cattle but the milk belongs to the women. In Mukweh, some labour is paid with liquid milk. In Sabga peak labour demand in the rainy season is for training of first-calf cows for milking.

Individual interviews revealed that men constituted only 16.8% of dairy operators compared to 83.2% of women. 71% of respondents fell within the age range of 24 to 50 years while 29% was above 50 years. Furthermore 49% of farmers had not received training in dairy production. The gender representation of dairy farmers in the North West Region is illustrated in Figure 3.1.5.

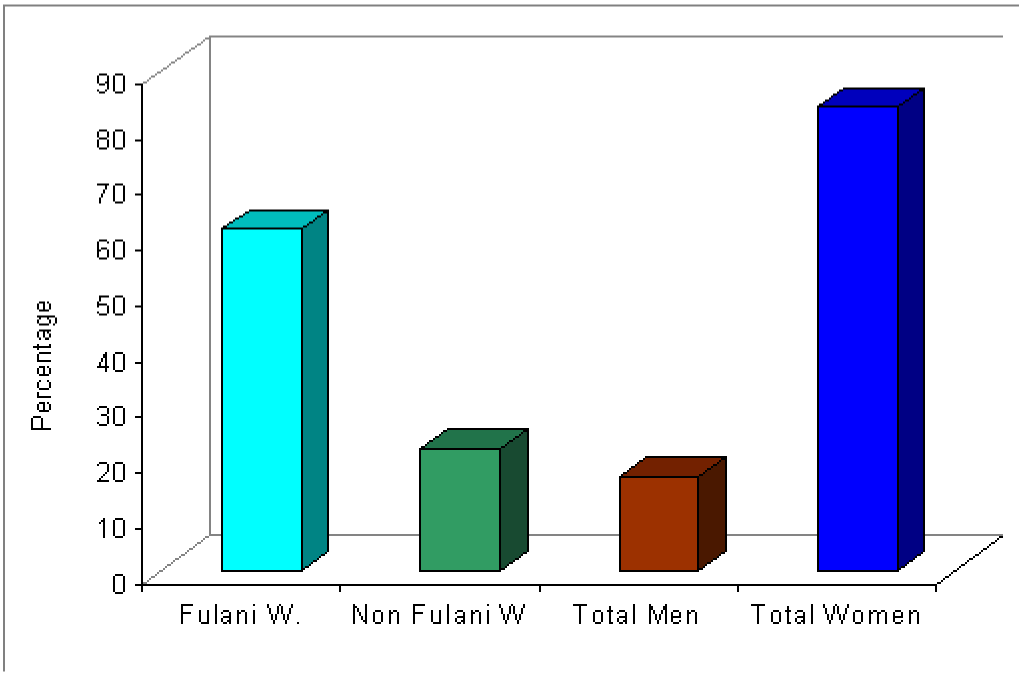

Figure 3.1.5. Gender representation of dairy farmers

The high percentage of the Fulani women clearly shows that they are more involved in dairy activities than the None Fulani women. Thus, the role of the women in dairy production is of prime importance. They need motivation and more education in this sector. If the milk production sector fails, then the livelihood of the Fulani women will be the most affected.

3.1.4.9. Health

Major dairy cattle diseases in the Western highland are in order of importance ticks and tick born diseases: babesiosis, anaplasmosis, dermatophilosis, cowdriosis; mastitis in milking cows; diarrhea; foot and mouth disease (FMD); black quarter; ephemeral fever and ear infection. Veterinary services are provided by non-governmental organizations or private veterinarians. Vaccination is done yearly against black quarter, haemorrhagic septicaemia, and contagious bovine pleuropneumonia. Only few farmers spray their dairy animals. Hand de-ticking is more common. It is the fear of ticks that prevents some farmers from sending crossbred cattle in low and hot lands on transhumance during the dry season. Many traditional farmers make use of ethno-veterinary medicine (Sabaga, Jakiri, and Bamdzeng).

3.1.4.10. Marketing

3.1.4.10.1. Stakeholders

Main stakeholders for dairy production in the Western Highland of Cameroon are: the non-government organization Heifer Project International (HPI), the processing company Sotramilk, the Tadu dairy cooperative, the Ministry of Livestock and Fisheries, feed companies and the Institute of Agricultural Research for Development.

3.1.4.10.2. HPI

This non-governmental organization (NGO) is based in the United States of America. In Cameroon it is a representation of the intensive form of management. In 1974, in collaboration with the institute of animal research (IRZ), HPI provided the initial shipment of purebred Holstein and Jersey dairy cattle to Bambui research station. Recently, more purebred in-calf heifers are being provided directly to farmers.

3.1.4.10.3. Sotramilk

It is a plant aided by a Dutch non-governmental organization which started operating in 1995 with the aim of boosting local milk production. It operates by buying milk from neighbouring farmers in a radius of 10 km. The factory has a capacity for processing 12000 litres of milk a day. But it collects only a maximum of 300 litres per day in the dry season and 600 litres per day in the rainy season. Therefore this fresh milk is usually combined with imported powder milk to make various products such as: Gudali and Edam cheese, and natural and fruit yoghurt (cherry, pineapple). Milk collection is limited because of bad roads. However farmers who do arrange for their milk to be delivered to the factory are compensated for transport.

3.1.4.10.4. Tadu Dairy Cooperative Society (TDCS)

TDCS is a cooperative organization established in 1992 following an intensive training provided by Land 'O' Lakes, Inc. and the United States Agency for International Development (USAID). The main service provided to the members is artificial insemination with Holstein and Brahman semen. TDCS was initially made up of over 200 pastoralists. Up to 1000 to 3000 liters of milk could be collected daily during the dry and rainy season respectively. However the road network is very bad and the market is limited to the neigbouring Kumbo town. Consequently TDCS is planning to build a processing plant.

3.1.4.10.5. Feed companies

There are many feed companies in provincial towns. The following are ingredients commonly found in these shops: cotton seed cake, wheat bran, rice bran, soya bean cake, fish meal, palm kernel cake, bone ash, limestone meal, blood meal (Table III.I.4). Maize is usually sold for human consumption although it is also bought by animal producers.

3.1.4.11. Use of money from sales of milk

In Fulani communities (pastoralist tendency), milk belongs to the women and so money from milk sales is not used for cattle but for personal needs, household needs and children school fees. In native communities, this money can also be used for cattle. Some people suggested that if they had more money from milk, they would send their children to secondary school and university or open other businesses.

3.1.4.12. Farmers' access to services and information

Farmers acquire information and services mainly through NGOs and the government programme of agricultural extension services. Although internet services are available in the regional head quarters, not many farmers are formally educated to be interested to this source of information. What is needed is to provide adequate information to these organizations for it to be well used by farmers. Therefore if the relationship of research continues to be good with these stakeholders, there will be a good flow of information. Most of the veterinary services are provided by HPI as far as Holstein cows are concerned. Otherwise, private veterinarians offer payable consultations.

Table III.1.4. Prices of feed ingredients found in shops in Bamenda (1000FCFA= $ 1.5)

Ingredient	Average price, FCFA /kg	Availability
Cotton seed cake	140	Good but price depends on good roads from place of production in northern part of the country
Palm kernel cake	60	Very good
Fish meal	600	Poor
Soya beans cake	500	Poor
Whole soya beans	300	Good
Wheat bran	75	Very good
Rice bran	50	Seasonal
Bone meal	200	Good
Limestone	200	Good
Blood meal	400	Scarce
Maize	200	Very good but price goes up in late dry season to early rainy season

3.1.4.13. Other activities

Dairy farmers commonly keep other farm animals such as scavenging chickens, goats, sheep and horses. Non-Muslims keep pigs. All farmers visited plant crops, and grow maize, potatoes, sweat potatoes, coco yams, beans or coffee. Some farmers are also involved in activities such as cattle trading, small businesses and apiculture. Some Fundong dairy farmers own fishponds.

3.1.4.14. Constraints

Major constraints of dairy production in the region were ranked by order of importance as follows:

a. Marketing: Poor marketing opportunities and long distances to market

The processing company Sotramilk has a limited sphere of milk collection because of high collection costs. Also, farmers supplying milk to the factory complain of the price of fresh milk being low.

Farmers' suggestions to alleviate constraint: Break the monopoly of Sotramilk or let the company raise prices; let the government provide financial support to farmers.

Recommendation from research team: to this constraint, farmers were advised to arrange milk collection in groups and transportation to Sotramilk.

Farmers of Fundong and Bafut who have adopted this system no longer suffer from a marketing problem.

Milk transport is one of the most important problems faced by farmers. In the traditional system with large herds, individual cows have a low daily production but farmers can milk a large number of animals to have a good quantity of milk per herd. Unfortunately, these farms are far from the market and roads are bad thus milk easily spoils during transportation. The Lacto-peroxydase system could be used to prolong the shelf life of milk. Farmers could also be provided with technologies for processing milk into cheese if the market is available.

When considering the peri urban production system, the most important constraint was the lack of improved breeds for milk production (Holstein Friesian).

b. Feeding: limited grazing land and poor supplementation of cattle

Because of encroachment of pastures by crop farmers, dairy farmers found themselves with limited grazing lands. They also lack knowledge of good feed compounding. Some areas (Mukweh in Fundong) had their improved pastures permanently invaded by stray goats from neighbours. In Tadu most pastures are seriously invaded by bracken fern. There was consequently an inadequate feeding during the dry season in most parts of the region. Moreover, farmers find the cost of concentrate high and the cut and carry system tedious.

Farmers suggested as a solution to land conflicts that the government secure communal grazing lands.

Recommendation from research team: Make concentrates more available at low cost by formulating in a linear programme cheap rations using local available products. Research should also find a way of making grass cutting less tedious for farmers employing zero grazing (cut-and-carry) management. This could be done by devising a local chopper adapted to the farm size and which could be acquired by dairy groups.

Previously, dairy rations formulated by researchers in the regions, though efficient, were not very profitable because of inclusion of high cost ingredients. This constraint can be alleviated by extending improved and cheaper rations to farmers, and providing them with extension leaflets in feeding methods for dairy cows.

c. Limited health control

In some places, drugs and veterinary services were not always available.

Recommendation from the research team: Farmers should invest more money in health control and should organize themselves within dairy groups for veterinary care in order to lower cost. Private veterinarians are available for consultation.

The government no longer provides free veterinary services to farmers as the sector has been liberalized. It is good to make farmers understand the economic loss they incur with poor health control. The Economic Opportunity Survey will be helpful in this area. Previously, veterinary researchers worked to identify diseases and pathogens hindering cattle productivity. No economic evaluation of the impact of disease has been done in the region.

d. Inadequate knowledge in processing, conservation and storage of milk

Many farmers complained of their milk getting bad in a short time.

Recommendation from the research team: Train farmers in hygiene, processing and preservation methods. The lacto-peroxydase system, tested in the Sabga, Santa and Bali region, can extend the shelf life of milk to an additional 6 hours or more if the milk is kept in cold water. This constraint will be alleviated by extending processing and conservation methods.

e. Breeding: poor reproductive management and prolonged calving interval

In traditional management where fencing is rare, bulls breed cows without control. This was the case in Jakiri and Mbamzeng. On the other hand, farmers using AI did not always have semen or purebred bulls available to them. There was also a great failure of conception in inseminated cows.

Recommendations: Improve the breeding program. This constraint though 5^{th} in general ranking, comes among the first in the peri urban system which is the most market-oriented. Farmers complained of lacking good dairy animals. The causes of the poor reproductive performance need to be investigated and advice given to farmers. There is also a need to emphasize good breeding management through extension leaflets.

Artificial insemination has proven to be less sustainable because of the high cost of liquid nitrogen and conception failure due to the AI technician not getting 'heat' information early enough or getting to the farm at an appropriate time. Therefore, it is advisable that dairy groups acquire bulls. It is also possible in areas where the main problem is high cost of liquid nitrogen that chilled semen be used for insemination.

f. Farming management

Lack of water in the dry season.

Recommendation: Farmers could pay people to carry water when they use a zero grazing scheme.

g. Poor Housing

Many milking stables were in a bad state and fencing was poor.

Recommendation: Provide extension services for housing and fencing.

h. Poor organization of group

Recommendation: Reorganize groups to be more dynamic.

i. Others: *limited number of dairy cows and poor record keeping*

3.1.4.15. Dairy production systems

Dairy cattle management systems of the region are summarized in Table III.1.5. In the region, five main dairy production systems have been identified. Recommendations from stakeholders are indicated in Table III.1.6.

Table III.1.5. Some characteristics of the dairy production systems.

Production system	**zero grazing**	**Peri-urban**	**Semi intensive**	**Transhumance**	**Improved extensive**
Breed	*High yielding exotic	*Exotic or/and crossbreeds		*Local	*Crossbreeds
Confinement	Total stall feeding. Improved grass. Some supplementation	Stall feeding. Rotational grazing. Improved grass. Cheap agro industrial by- products	*Rotational grazing some supplementation	Communal grazing. *Transhumance of non lactating adult cattle	*Communal grazing
Cropping activities	*Owners primarily involved in cropping activities	Integrated to dairying	Integrated to dairying	Limited	Limited
Marketing	*Not always available	*Very good Market oriented	*Not always available	Difficult	Difficult
Number of cattle	< 5	< 10	<50	hundreds	hundreds
Dominant tribe Gender	Native men or women	Native men or women	Native men	Fulani men	Fulani men
Main constraint	Poor market	Poor reproductive performance. Lack of good dairy breeds. Heavy work load in cutting and chopping grass.	Limited knowledge in feeding management	Lack of sufficient grazing land	Lack of sufficient grazing land
Main herd purpose	Dairy/Manure	Dairy/ Manure/ Beef	Dairy / beef	Beef/dairy	Beef/dairy
Health care	average	Good	Good	Poor	Good
Consequence	Ownership of cattle is due to incentives from NGOs	Farmers very opened to accepting extension packages and investing in dairy cows	Farmers drive production to market demands (meat or milk)	Traditional way of management could disappear or seriously reduced due to land disputes	Open to limited improvement of management. Could adapt to changing environment if they could have more crossbreeds and continue to manage them well
Exemple of site	Meli; Fundong	Nkwen	Bafut	Sabga	Jakiri; Bamdzeng

* *Main characteristic*

Table III.1.6. General recommendations from processing plant agents, from regional government livestock office, from non-governmental organizations and from cooperatives

Source of recommendation	**To Farmers**	**To Extension Services**	**To Sotramilk**	**To Research**	**To Government investing bodies**
SOTRAMILK	Improve cattle feeding	Show the importance of milk to families		Conduct seminars on feeding in order for farmers to grasp the need to improving feeding	Create a dairy technology School. Provide subventions to farmers like in some other African countries
Government livestock department	Must drive management towards intensification because of land conflicts resulting from reduction in communal pastures	Show the necessity of concentrate to farmers. Show need of agro industrial by-products	Stimulate producers	Be involved in extension	Be also involved in dairy cattle production. Must not only put emphasis on small livestock species
Non-Governmental organizations Farmers' cooperatives	Improve in milk preservation		1. Share profits with farmers by increasing price of milk 2. Standardise measurement of farmers milk, either in litre orkg. 3. Measure milk on with farmers and issue receipts to farmers at collection point. 4. Also collect evening milk.	1. Investigate low calving rate and relationship to plane of nutrition. 2. Number of improved breed animals limited; so set up nucleus herd for multiplication. 3. Produce extension leaflets in all aspects of dairy management 4. Find balanced dairy rations adapted to local environment. 5. Find baseline data related to health.	1. Provide subsidies to farmers. 2. Limit licence for import of dairy products

3.1.5. Discussion

3.1.5.1. Feeding, breeds, production, marketing and health

The calendar of activities of the region shows that after the harvesting season, crop residues can be fed to stall-fed cattle in the dry season or as the practice is in mixed communities (pastoratists/crop farmers), cattle can be sent to graze standing crop residues such as maize stovers. In Kenya, Stall *at al* (2001) found that crop residues (maize stovers) used for dairy cattle had gone up while the use of concentrate and roadside grasses was reduced. Chopping grass for Holstein cows is tedious in the zero grazing system. These farms could have a tremendous help if research could design a small scale chopper to be used by farmers' groups.

All dairy systems in the North West Region are involved in cropping activities; although in varying degrees as described in Figure 3.1.6.

It is expected that farmers more involved in cropping will feed more crop residues to cattle. Therefore, they may not have severe feeding shortages in the dry season. On the other hand the fear is that these farmers rely more on the residues at the expense of grass. It is therefore necessary to keep encouraging crop farmers to cultivate improved grass and legumes.

The information on ingredients used in concentrate shows that most farmers use maize and whole soya bean flour in the feed. But this seems expensive as there are by-products such as wheat bran and cotton seed cake which can more economically be used. Palm kernel cake is cheap but is not widely used as farmers complain of a drop in milk yield when including it in high proportions in home-made concentrate.

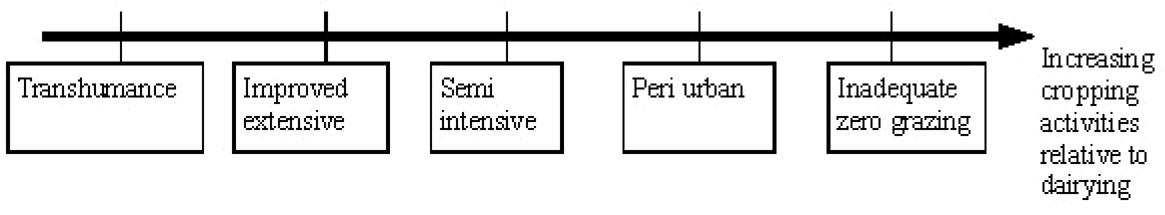

Figure 3.1.6. Integration of dairy systems with cropping activities that favours the feeding of crop residues

This by-product is not very palatable (McDonald *et al*, 1988) and has residual oil content which can impair microbial activity of the rumen. Therefore, the recommendation of using a linear program to formulate dairy rations seems appropriate.

The only high yielding pure milk breed found in the region was Holstein. In the past, the smaller size Jersey was also present. Farmers of the Western Highlands of Cameroon prefer Holstein Friesian which is also good for beef production. The increasing use of the Holstein Friesian breed indicates that in market oriented farms, farmers prefer high yielding animals to improve milk production per cow. This confirms their willingness to adopt new technologies. A company or organization set up to produce these animals will be of great help to the farmers. In Kenya (Stall *et al*, 2001), although the predominant dairy breed is Holstein (42%), there are also other exotic milk breeds: Ayrshire (18%); Guernsey (12%), Jersey (3%); the local breeds representing 25% of milking animals. In Cameroon, production from crosses is fairly good. These animals are well adapted to the semi intensive and to the improved extensive management. Twice daily milking was found to increase milk production by over 30% compared to once-daily milking but the market in many places is not good. That is why many farmers do not do milk more than once daily.

Main factors influencing milk production have been outlined in Figure 3.1.7. Fresh milk price can be increased by reduced importation. This is in fact what has happened since 1994 because of the devaluation of the CFA currency. The milk price can also be put up by processing plants.

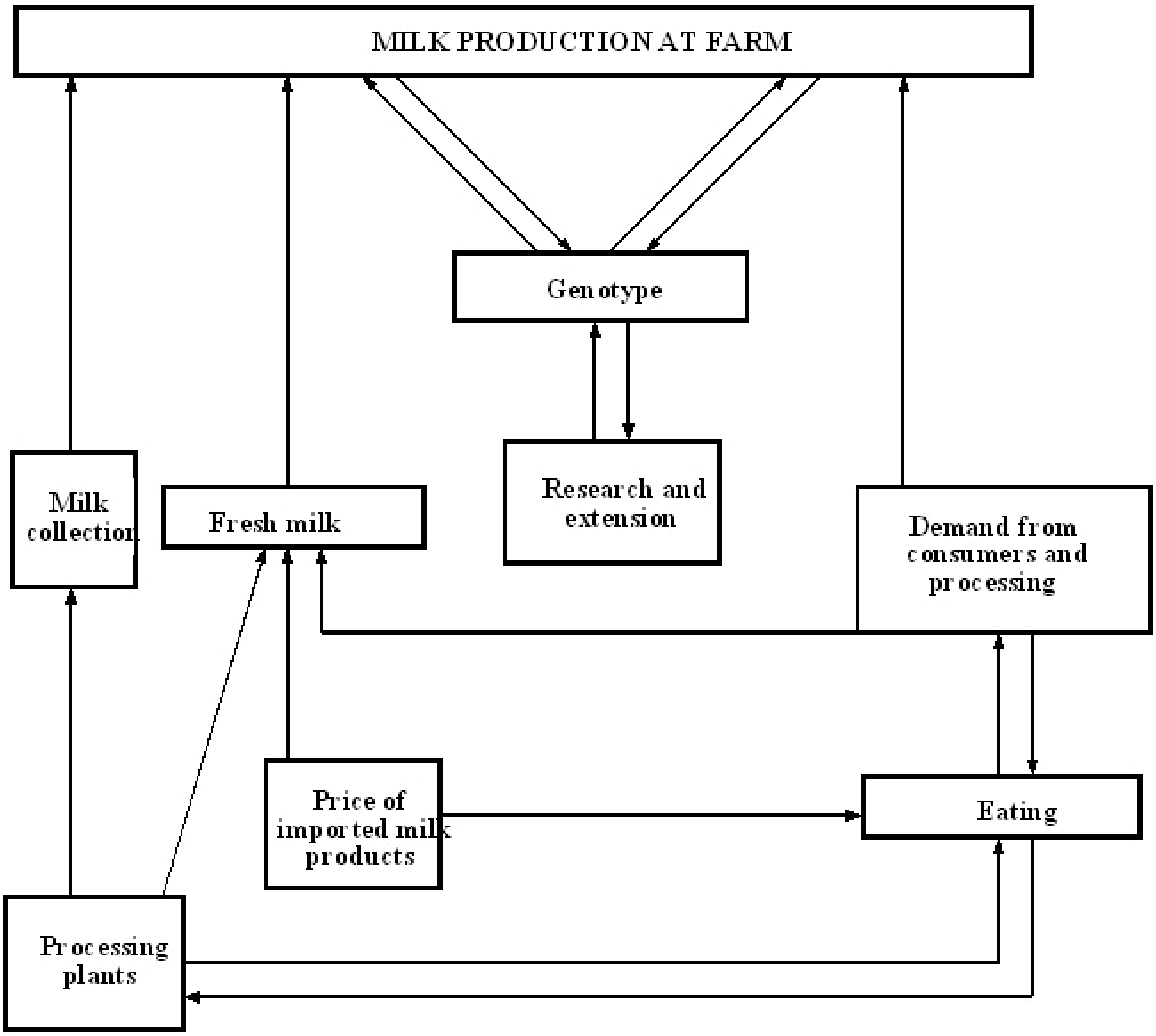

Figure 3.1.7. Main factors influencing milk production in Cameroon

Lastly in open markets, a high consumer demand increases price. When the milk price is up, farmers can modify their management by improving it. They can also reduce culling rates of female dairy animals. Others can purchase high yielding animals which will help them make more money. In contrast, when price is low, culling rates go high in favour of meat and management is poor. Processing plants sometimes modify eating habits of Cameroonians by creating new products. When consumer demand for fresh milk and milk products is high, milk production can increase because many people purchase products directly from farmers. As in the first case, the need of increased production at farm level positively influences type of breed kept and management. Research and extension bodies intervene mainly in breeds, breeding and management. At the moment, there is no possibility of over production which could negatively influence price. This confirms the findings of Tambi and Vabi (1994) that price is relatively inflexible to changes in market supply. The demand for milk is very high in urban areas and there is good prospect for farmers if production increases. Research and extension consequently have a lot to do in improving management, especially in the peri-urban system.

The pattern of milk supplies to the processing plant indicates that there is less milk available in the dry season. Consequently the plant must import powder milk at that period to meet a high demand in milk products. However, the plant could encourage farmers to keep up with the production in the dry season by paying a higher price of milk. The informal marketing could be improved by farmers' groups organizing themselves to preserve milk and market it together.

As far as consumption is concerned, many people do not know the importance of milk in human nutrition. Fresh milk is not also common in eating habits of non pastoralist Cameroonians. If many farmers do not sell their milk, it is simply because of the lack of market. In Kenya (ibid) 37% of dairy farmers' households refuse to sell their milk. In

Cameroon, most dairy operators are women. This is an indication that women constitute a stronger force in milk production and marketing than the men do. This agrees with the findings of Kameni (1994). This also occurs in Zanzibar, Tanzania where 75% of them are women (Biwi, 1992). This fact is a good prospect for women's welfare in rural Cameroon. If dairy production increases, women will be the first beneficiaries. They need motivation and more education in this sector. Otherwise, their livelihood will be most affected.

In health aspects, worm infestation was not listed as a problem. Perhaps because much ethonovetenary drugs are used to control worms (Nfi *et al*, 1999). It is also possible that worm infestation causes much morbidity thus reducing milk yield. It would be better for farmers to make sure that worms are controlled even if cows do not clinically suffer. Most important diseases were found to be tick-born; meanwhile in Nigerian dairy commercial farms, it is mastitis (Onwuka *et al*, 1995). In the semi-intensive system, specialized dairy breeds are sent for grazing at the time tick infestation is high in pasture (Bayemi *et al*, 1999). Therefore there is a need to control this challenge with pour-on acaricides so that exotic breeds or crossbreeds are not put at risk.

3.1.5.2. Systems

Nell (1992) described 5 dairy production systems in Sub Saharian Africa: pastoral, agro pastoral, mixed farming, intensive and peri urban. These systems are found in Cameroon in various stages. However, the intensive system if understood as leading to industrial milk production was not found in the western Highlands where most farmers practice dairying at a small scale level. Previously only three dairy systems were found in Cameroon: pastoral, semi intensive and intensive (Kameni *et al*, 1999). Over the years, with the growing extension of high yielding dairy breeds, the zero grazing system has been encouraged. In the past, this intensive system was not encouraged as there was a fear that farmers would not be able to care for heavier animals such as Holstein. In fact, this is what happens in some of the zero grazing farms where farmers, because of the lack of market, neglect these animals. However, in the peri-urban area, many farmers adopt good management and would like to increase the number of Holstein cows in their farms. Dairying has also specialized in the peri-urban areas where marketing is good. More crop farmers get involved in dairying. In Tunisia, the total confinement system is practiced by farmers without pastures (Lahmar *et al*, 2003). But in Cameroon, many such farmers cultivate improved grass in a cut-and-carry system.

In Tanzania (MOAC, 1998), four systems are found in small scale dairying: two intensive urban systems and two semi intensive urban, with manure being very valuable alongside milk or meat. Farmers in that country also use crosses in the intensive system while in the North West of Cameroon, crosses are only used in the semi-intensive. The semi zero grazing found in Uganda (ILRI, 1996) or Kenya was not found in this study.

3.1.5.3. Constraints

In Uganda, the primary constraint was seasonal fluctuation in quantity and quality of feed resources. This is similar to Kenya and Tanzania. This must be related to the fact that dairying is more developed in those countries and dairy cooperatives well established. In Cameroon, the first constraint was market related when considering the whole region. A lot more needs to be done to channel the milk produced in rural areas to urban centers and educate more people in the use of milk in their diets. This can be done by processing plants, cooperatives or NGOs. However in the semi intensive and zero grazing peri urban systems where the problem of marketing is reduced, farmers complain of the lack of good dairy breeds. This shows their desire to improve production. Their willingness to invest in the purchase of high yielding dairy cows is an indication that small scale dairy business is profitable. In Zimbabwe (Francis and Sibanda, 2001), the first constraint was poor reproductive performance followed by inadequate amount and low quality forage. This pattern is similar to the peri-urban systems of the North West Region.

Main constraints of dairy production in this region could be tackled through extension of appropriate methods adapted to each system. In fact, recommendations from farmers show that government, research and extension services are keys to the solution to many of these problems

3.1.5.4. Conclusion

- Five dairy production systems were found in the North West Region of Cameroon: transhumance, improved extensive, semi-intensive, peri-urban, and zero-grazing.
- Constraints hindering production in these systems are by order of importance related marketing opportunities and long distances to market, feeding, limited health control, storage and processing, reproduction and management.
- In market-oriented farms, main constraints are poor reproduction and inadequate feeding.
- Main factors influencing production are milk processing plant, fresh milk price and management. The marketing channel involves processing plants and open markets.
- Recommendations were geared towards government bodies and research working more to helping farmers to resolving constraints. However, processing plants were also advised to finding ways of establishing more confidence with farmers in the measurement of their milk.
- The fact that women are the gender more involved in milk production and benefiting more of the marketing is a good prospect for their welfare if production improves.

- The most urgent interventions to follow in market oriented farms seems to be tackling constraints of failure in reproduction and heavy work load in chopping grass. This is coupled with the extension of improved methods feeding and breeding methods.

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3.2. Economic opportunity survey of small scale dairy farms of the North West Province of Cameroon

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3.2.1. Abstract

An economic opportunity survey (EOS) was conducted on dairy farms in the North West Region of Cameroon. Results showed that median (range) number of cows in milk per farm was 0.6 (0-4) and six (3-12) in the zero grazing and transhumance systems, respectively. Medians (range) of three (0-24) and four (3-10) litres of milk were sold per farm per day, corresponding to 30% and 60% of milk produced. 24% and 13% of total cattle per herd were milking cows in the zero grazing and transhumance systems respectively. Median milk production per cow on one day was two (0-25) and two (1-3) litres. Median calf production interval was 14.5 (12-25) and. 21.5 (14-29) months. More milk produced per day represented the best economic opportunity in both systems while reduced age at first calving and longer lactation length were the next in both. Wastage of milk through spoilage from poor hygiene and lack of cooling was a major problem. Holstein cows, which were in the zero grazing system, had unexpectedly short lactations. Constraints identified led to the setting up of interventions of training and advice for farmers and of better nutrition.

Key Words: Cattle, Cameroon, economic opportunity, milk, small-scale dairy farm.

3.2.2. Introduction

Improving milk production is a key issue for the livestock industries of many countries, whether it is expressed in terms of quantity as in most developing countries or in terms of quality as in the European Union. In 1999, the per capita milk production of Cameroon was only 12.8kg, while the average value for Africa as a whole was 34kg. At the same time, milk consumption per capita in Cameroon was 15.3kg (FAO, 2000). Because of this deficit, milk products are imported in the country to cover it up. This importation sends hard currency out of the country that could otherwise be used in the development. Furthermore, milk products can often be imported at prices far lower than that for milk produced within the country, rendering local farmers more vulnerable to loss of markets. Nevertheless, in Cameroon, local milk competes quite efficiently with imported milk (Bayemi *et al.*, 2005a). Therefore, an effort is being made by the government and Non-governmental Organizations to increase local milk production and, as a result, economic returns.

In a dairy herd, many factors influence economic returns. These factors may be related to the animal itself, to the management or to financial inputs. Similarly, some constraints cost the farmer much more than others. If these main constraints could be identified and overcome, economic returns would be expected to improve substantially. Such components of production are called economic opportunities (Nordlund *et al*, 2007). The objective of this research was to evaluate the state of small-scale dairy farms in Cameroon and to determine the most important economic opportunities, with the eventual goal of addressing such opportunities in an integrated manner.

3.2.3. Materials and methods

3.2.3.1. Area of study

The North West Region of Cameroon is located in the mid to high altitude zone of the country that lies between latitudes 5°20' and 7°00' North and longitudes 9°40' and 11°10' East. Altitudes range from 300 to 3000 metres above sea level. The climate is characterized by two distinct seasons: Dry from November to mid March and rainy from mid March to October. Annual rainfall varies between 1300-3000 mm, with a mean of 2000 mm. Daily minimum and maximum temperatures have means of 15.5°C and 24.5°C, respectively, although temperatures can exceed 30°C. The human population is estimated at 1.82 million inhabitants with an annual growth rate of 3.1% (Winrock International, 1992). The proportion of the population involved in agriculture is estimated to be 72%. Agricultural products from low to medium altitudes include: oil palm, cocoa, Robusta coffee, fruit trees, cocoyam, maize, small livestock, rice, and groundnuts. The high altitude (above 1400m) products include: solanum potato, Arabica coffee, vegetables and small and large ruminants (PNVRA, 2002).

3.2.3.2. Animals

Five small-scale dairy production systems are found in the region: transhumance, improved extensive, semi-intensive, zero grazing and peri-urban (Bayemi *et al,* 2005b). In the transhumance system, cattle graze on communal lands and spend nights in open pastures. The cattle are of local breeds - Gudali and Red and White Fulani- (*Bos indicus*). In the zero grazing management systems, grass is cut, chopped and provided to animals in feeding troughs. The majority of these cattle are Holsteins or crosses (*Bos taurus* X *Bos indicus*) and are permanently housed in stables. Cows are offered concentrate diets during milking. The semi-intensive farms have sleeping paddocks or sheds constructed of wood with zinc or grass roofs. In the last two systems, cows are milked in sheds with concrete floors. Many farmers use purebred Holstein bulls for natural mating.

Major dairy cattle diseases in the region are, in order of importance (Bayemi *et al*, 2005b), ticks and tick born diseases (babesiosis, anaplasmosis, dermatophilosis, cowdriosis), mastitis in lactating cows, diarrhoea, foot and mouth disease, black quarter and ephemeral fever. Gastrointestinal parasites are also very prevalent. Non-governmental organizations or private veterinarians provide veterinary services. Vaccination is done yearly against black quarter, haemorrhagic septicaemia and contagious bovine pleuropneumonia. Only few farmers spray dairy animals against ticks; hand picking of ticks is more common.

3.2.3.3. Survey

Sixty-one farms were selected for the Economic Opportunity Survey (EOS) on the basis that they were market-oriented and easily accessible. Most of the farms (51 of 61) were zero grazing, while the other 10 were from the transhumance system. Each farmer was asked to complete a survey in June and July. The survey forms used were designed by Nordlund *et al* (2007). The responses to the questionnaire were used to establish a database consisting of four sections:

(i) Milk production on one day: Total production on the day prior to the visit divided by the number of lactating cows.

(ii) Expenses for cattle health care and feeds: Sum of purchased feeds, veterinary services and medicines during the last year.

(iii) Inventory of herd culls and deaths: Number of cattle sold or dead during the past year, average price per class of animal.

(iv) Milk and calf production (calving) per cow. This section describes current milk production per cow on one day, calving date, number of calves per lifetime, age at first calving, calf production and days-in-milk.

A fifth section was necessary for setting targets used for evaluating farm performance. The results from the survey were downloaded into an "EOS output" file, comparing individual farms with the 20% or 80% percentile (Table III.2.1) and calculating economic opportunities using the approach developed by Nordlund *et al* (2007). For figures where a higher value is desirable, e.g. lactation length, milk yield, percentage of lactating cows relative to total cattle, the 80th percentile of the data collected was used. Where lower values are better, the 20th percentile was used, e.g. calf mortality rate, age at first calving and calf production interval. The lactation length of some cows in the zero grazing reached 500 days. Such figures were discarded to consider the standard lactation length of 305 days of Holstein cows as the target. The lactation length target of transhumance cows was taken from maximum values (Bayemi *et al,* 2005a) and so 225 days was used.

Table III.2.1. Targets used in two dairy production systems in North Western Cameroon to assess economic opportunities for gain.

	Transhumance	Zero grazing
Percentage of milk and milk products sold of milk produced[a]	60%	80%
Calf mortality rate (past 12 months)[b]	0%	0%
Average age at first calving - data for first and second lactation cows only - (months)[b]	31	27
Calf production interval (months)[b]	17	12
Average lactation length (days)	225	305
Lactating cows as a% of total cows[a]	60%	
Lactating cows as% of all cattle[a]	30%	50%
Milk production per cow on one day (litres)[a]	3	15

[a]80th percentile of data collected used as target
[b]20th percentile of data collected used as target

Farmers occasionally ignored forage consumption on the input forms. In these cases, forage intake was roughly estimated relative to live weight (McDonald *et al,* 1988), assuming that access was unlimited, and forage dry matter in the season that the survey was conducted. In the transhumance system forage cost was estimated from the salary used to pay herdsmen for taking animals for grazing. In the zero grazing system, the cost was calculated from expenditures on planting, weeding, cutting, fertilizing and chopping of grass.

3.2.4. Results

Table III.2.2 shows that the transhumance system used more family labour than did the zero grazing system and had no need to hire workers from off the farm, despite the greater need for labour. Only a limited land area is used for pasture improvement. Nine out of the 10 transhumance farmers owned no land at all with the other one owning 130 hectares. Farmers employing the transhumance system consumed slightly more milk per family than farmers practicing the zero grazing system. This is probably an inevitable finding because 22 out of 51 zero grazed farms were producing no milk at all at the time (Table III.2.2). Therefore milk is not traditionally part of their diet, whereas it is for the transhumance pastoralists. The highest producing farms of the zero grazing system sold 80% of their milk. Only one farm in the transhumance system gave milk separately to calves. In this system, calves usually take residual milk and they are taken off the cow in the evening. Calves here are weaned between seven and 12 months while the calves of zero grazing cows are weaned at four months.

Six farms in the zero grazing system were milking their cows once a day in the morning with cows producing an average of four litres per cow on one day and having an average lactation length of 173 days. This compared to eight litres per cow on one day in the remaining 23 farms, where cows were in milk, and on twice a day milking, where the average lactation length was 296 days.

Table III.2.2. Median of cattle, labour, land and milk usages per farm in two dairy production systems in North Western Cameroon.

	Zero grazing system		Transhumance system	
	Median (range)	**Number of farms**	**Median (range)**	**Number of farms**
Number of cattle per herd	4 (1-22)	51	47 (16-80)	10
Number of lactating cows per herd	0.6 (0-4)	51	6 (3-12)	10
Family labour per farm (men/year)	3 (0-15)	51	8.5 (6-10)	10
Hired Labour per farm (men/year)	0 (0-2)	51	0	10
Total land owned (ha)	3 (0-8)	51	0 (0-130)	10
Improved Pasture per farm (ha)	2 (0-33)	51	0.75 (0.5-1)	10
Lactating cows as % of total cows	1 (0-100)	44	37 (10-60)	10
Total milk produced (litres on-one-day) [a]	5 (0-30)	51	7 (4-55)	10
Milk sold/produced [a]	0.3 (0-1) [a]	29	0.60 (0.2-0.8)	10
Sold milk (litres/day) [a]	3 (0-24) [a]	27	4 (3-10)	10
Family used milk (litres/day)	1 (0-5) [a]	29	3 (1-7)	10
Fed to calves (litres/day)	0 (0-5) [a]	26	Not applicable	-
Other uses of milk (litres/day)	0 (0-3) [a]	3	None	-

[a]22 out of 51 zero grazed farms were producing no milk at the time of the survey. Data with superscript [a] are only from those producing milk at the time.

Few farms in either system processed their milk prior to selling it. However, two farmers of the transhumance system processed large quantities of milk, each having more than 10 times the output of the largest zero grazing herd that processed milk. The common products made were yoghurt, traditional sour milk and butter oil.

A significant proportion of milk appeared to be wasted through spoilage, with an average of one litre per farm per day a considered estimate by researchers.

Health care and feeding costs were quite variable (Table III.2.3). Some farmers used ethno-veterinary medicine and therefore spent no money on health care. The total health care cost per farm was higher in the transhumance system because farmers paid for treatment for hundreds of cattle yet only a few cows are used for milking. Some individual zero grazing farms had high health costs and because of smaller herd size spent the most per cow on health. When transhumance farmers gave concentrates, the total cost was high (147%) compared to the income from milk sold. This was mainly due to salt feeding to many non-lactating animals. Although salt is not technically a concentrate, it was taken into account because it was part of the money spent for feeding.

Figure 3.2.1 presents statistics regarding cattle inventories in the two systems studied. As mentioned previously, on average the herds in the transhumance system include a high proportion of non-lactating cows: 13% lactating against 24% in zero grazed herds. Although transhumance requires the cash flow from milk sales to support more costs for animal maintenance, it also allows for more selling of live animals: 15%, 16% and 4% of sold calves, bulls and cows compared to 0%, 5% and 1% respectively in the zero grazing.

Table III.2.3. Median (range) health care and feeding costs per farm in 61 farms in North Western Cameroon.

	Zero grazing system 51 farms	Transhumance system 10 farms
Total health care costs per farm per year ($)	18 (0-320)	110 (70-360)
Concentrate fed per cow per day (kg)	4 (0-10)	3 (2-4)[a]
Concentrate unit price ($/kg)	0.21 (0.1-0.33)	0.20 (0.2-0.7)
Total concentrate cost per cow per day ($)	1.06 (0-3.34) [b]	0.70 (0.4-2.8)
Total feeding cost per cow per day ($)	2.08 (0.5-2.14)	0.70 (0.4-2.8)

[a]Salt included as a concentrate
[b]Some zero grazing cows did not receive any concentrate

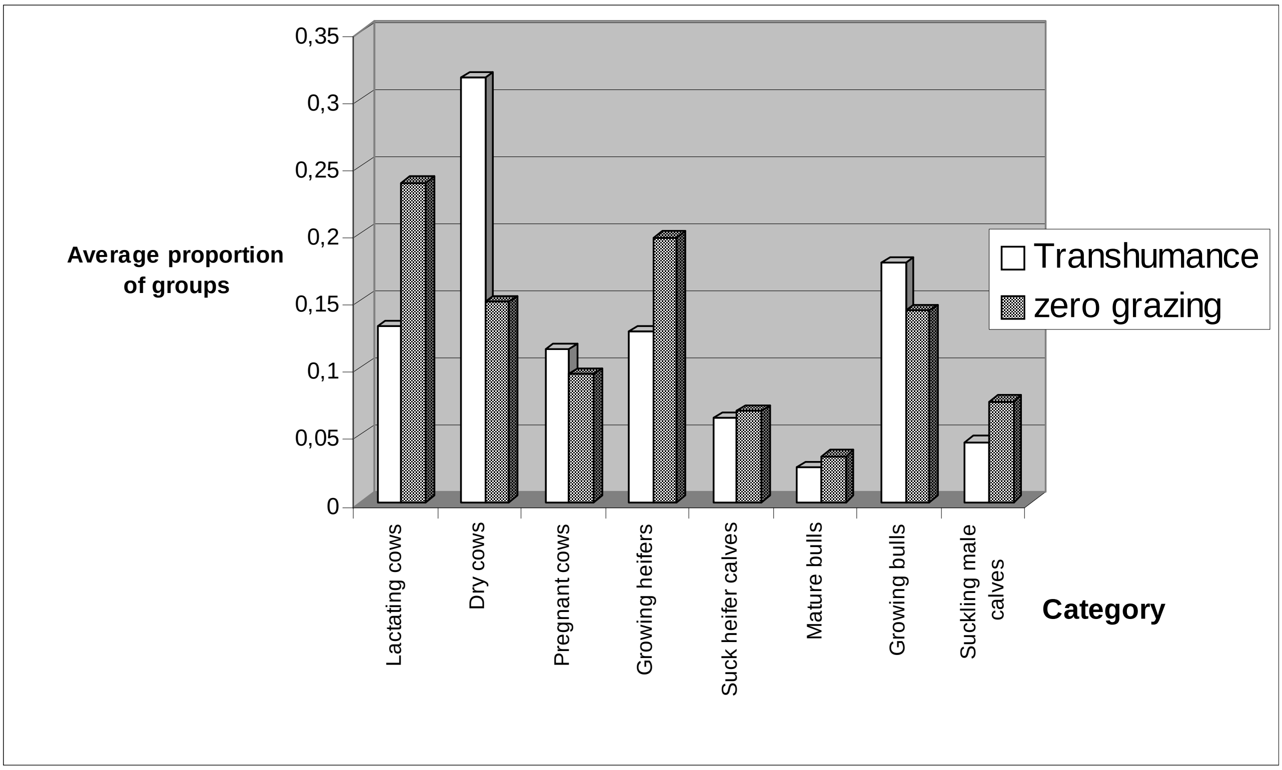

Figure 3.2.1. Herd structures in two small holder dairy production systems in North Western Cameroon

The transhumance system is effectively dual-purpose and more cows and bulls are sold, mostly for meat. In this system, beef production is more important for the farmer as it gives an average of $6000 yearly income per farm against $100 yearly income from milk. Consequently, women are usually in charge of milk production. In the zero grazing system, milk production gives an average of $600 yearly income to farmers against $350 from beef sales. Milk sales provide daily cash income helping farmers to support daily household needs.

Table III.2.4. compares the two farming systems for a number of parameters. The median milk production per lactating cow on-one-day was similar in both systems. The range was much greater in zero grazing herds. Twenty two were producing no milk on the day data was collected but a few cows were producing far more milk than any in the transhumance herds. The median age at first calving was also similar between the two systems but the data is less complete in zero grazing herds and the ranges show that some are very high. Calf production interval data is also similarly incomplete and widely ranging but appears longer in transhumance systems. Lactation lengths appear slightly shorter in transhumance herds.

Calf mortality was 12% per farm in the zero grazing while no calf was recorded dead in transhumance herds. It is quite likely that no calf died in the ten herds surveyed in the traditional system though this is not the case in all herds. Table III.2.5. shows average economic opportunities per herd in the two systems. In both, milk production offers the highest opportunity and could contribute much to increase income. Lactation length is also important, more so in transhumance herds where the large number of non-lactating cows influences the calculated result. Many farmers in zero grazing did not give enough information on health and breeding as they were not used to record keeping and thus only a limited number of them contributed to the investigation and the respective data in table III.2.5.

Table III.2.4. Some production parameters in smallholder dairy farms in North Western Cameroon

	Zero grazing system		Transhumance system	
	Median (Range)	Number of farms	Median (Range)	Number of farms
Milk per cow on-one-day (litres)	2 (0-25)	51	2 (1-3)	10
Age at first calving (months)	34 (25-68)	21	35 (25-43)	10
Calf production interval (months)	14.5 (12-25)	15	21.5 (14-29)	8
Lactation length (days)	223 (149-394)	16	213 (81-287)	9

Table III.2.5. Average economic opportunities in dollars ($) per farm in two systems of smallholder dairy farms in an Economic Opportunity Survey in North Western Cameroon

Opportunity	**Zero grazing system**	**Transhumance system**
Calf survival	12	0
Age at first calving	253	278
Calf production interval	32	11
Lactation length	103	738
Milk production	1302	890
Health care cost/cows	29	8

Due to the nature of the calculations in the EOS system (Nordlund *et al,* 2007) potential economic benefit from greater annual milk production is not included in the calculation for the effect of change in calf production interval.

3.2.5. Discussion

3.2.5.1. Labour, land and marketing

In the North West Region of Cameroon, the Fulani tribe has traditionally kept cattle and farmed them in a transhumance system. This activity is part of their way of life and the whole family is involved in herding. Most herdsmen who may be hired are often considered as members of the household. Although members of the family will take care of the cows in the zero grazing system, labour will also be hired, at least for tasks like grass cutting and chopping or cleaning.

Farmers involved in zero grazing systems are mostly those who used to be (or are still partly) involved in crop farming. The fact that they have been willing to reduce production of most crops and allocate large portions of their land to the raising of forages for dairy cattle suggests that they yield greater and/or more stable economic returns from dairying than from crop farming. This movement from crop to dairy production continues to gain popularity in the peri-urban areas of Bamenda (HPI, 1999). A similar trend has been observed in Kenya, where growing fodder in the cut-and-carry system decreases the land available for other types of agriculture (Staal *et al*, 2001). Data collected in this study (Table III.2.2) confirm that livestock keepers of the transhumance system graze their cattle in communal lands, because the private land available to them is very limited.

In addition to the on-farm constraints to dairy production, such as low production per cow and less than optimal reproduction, the lack of a consistent avenue for milk marketing is also restricting the expansion of milk production. This was the primary constraint found during the Participatory Rural Appraisal study (Bayemi *et al*, 2005b). There is no doubt that, if the market were available, more milk would be sold. Much is still needed to be done to increase the volume of milk sold by farmers.

One problem contributing to hurting commercial milk sales seems to be low keeping quality because of a general lack of access to systems for cooling milk to prevent early spoilage. The estimated average milk spoilage of one litre per farm per day is about 17% wastage of the milk produced. This is a significant loss with an economic opportunity of $12 per month or one third of a monthly salary of a herdsman. One traditional cooling method observed is to put pasteurised milk in a jar and deep it in cool water that is replaced every 6 hours. Such a method can keep the milk for 24 hours in the Western Highlands of Cameroon. But this depends on environmental temperatures that can go up to 40^{o}C. There is a need for educating farmers in milking hygiene to improve the milk quality. Without cool storage, milk must be consumed by the farmers' families or shared with neighbours or it will go bad. The lack of cooling systems is part of a vicious cycle that requires financial investment to break it. A Tanzanian experience shows that the higher the price per litre of milk, the less milk is kept for home consumption (MOAC, 1998). However, small scale farmers cannot afford to purchase the equipment needed to maintain a high quality of milk and obtain the higher prices. They are not always near enough to each other to cooperate and the quantity of milk produced per farm does not often justify big investment.

Dairy farmers owning purebred Holstein clean the udder with warm water and rub it with Vaseline before and after milking to ensure the tenderness of the udder for hand milking and reduce bacterial count in milk. Milking is done manually and milk is collected in buckets after tying the cow's hind legs. Teat dipping and mastitis testing are not practiced.

3.2.5.2. Diseases

Ticks and tick born diseases are the most important diseases threatening dairy production (Merlin *et al,* 1986). Holstein cattle are particularly susceptible to babesiosis, anaplasmosis, dermatophilosis and cowdriosis in this region. Luckily, animals of zero grazing farms are not much exposed to ticks, so cows do not often suffer from these diseases. In general, farms concerned in this study did not have any alarming health concerns, as shown by the PRA study (Bayemi *et al*, 2005b), and so health control did not present a good opportunity for economic gain (Table III.2.5). However, farmers should not neglect health control lest to lose valuable animals, especially in the zero grazing system.

3.2.5.3. Feeding

The amount of concentrates provided to traditional transhumance cattle was rather high, relative to the milk produced. A significant part of this was salt and many non-milk producing animals received this. As much as 18kg of salt per 30 cows per month may be given as the only 'concentrate' to traditional cows.

The Participatory Rural Appraisal (Bayemi *et al,* 2005b) revealed that low reproduction was a constraint to dairy production. The apparently high level of concentrate feeding – if not nearly all salt – does not look to be having a suitable effect. Many farmers did not include any adequate protein supplement in home made concentrate. Farmers used wheat or rice bran, maize, salt and bone meal. Njoya and Trenkle (1992) have already shown that inadequate protein supplementation was a limiting factor of grazing cattle production in Cameroon. The feed supplement used by transhumance farmers was then reformulated to include a higher percentage of cotton seed cake during the intervention phase of the project.

3.2.5.4. Lactation period and average age at first calving

Figure 3.2.1 shows the details of the distribution of cattle of different ages and sexes in the two systems. The zero grazing herds had approximately double the proportion of lactating cows and half the dry cows of the transhumance herds. These differences reflect the contrasts between the systems. The primary objective of the zero grazing system is milk production, whereas meat production is most important in the transhumance system. A high proportion of concentrate in the latter system is therefore used for beef production. In addition, the Holstein cattle breed is the most popular in the zero grazing system and less suitable for beef production. The average herd composition found in this study in zero grazing is similar to that reported for small scale dairy herds in Kenya (Staal *et al*, 2001). However no farmer in either system had only females among the adult animals (Figure 3.2.1). This result indicates that farmers in the small scale zero grazing systems, as well as the traditional transhumance, not only reared replacement heifers but also kept bulls for sale.

The poorer production parameters of farmers in zero grazing practising one milking per day suggested that twice a day milking could be a good intervention to boost milk production in those farms. The reasons for the one milking in the morning are that there is no market for evening milk and the absence of cooling facilities does not allow it to be kept and sold in a satisfactory condition the next morning. In which case interventions helping farmers in milk processing or better milk preservation will open the way to two milkings in those farms.

The median age at first calving was similar to that found in the Hilly zone of Bangladesh (Shamsuddin *et al*, 2006). This parameter is highly influenced by the way heifers are fed prior to puberty. O'Kelly *et al* (1988) found that growth-retarded calves reach puberty later, but other factors are also important. In the zero grazing system, nutrition may be sufficient to allow heifers to come into oestrus at two years of age (28% of farmers had cows that calved at 25 months of age – Table III.2.4 – but 20% of farms had cows calving at more that four years old) but farmers may fail to detect oestrus accurately too. Inefficient heat detection is usually a limiting factor of reproduction in small scale farms and a human management factor is almost always involved in differences in efficiency of heat detection (Cavestany and Galina, 2000). These farmers may need more training on the importance of and the proper approaches to oestrus detection. Furthermore, the use of a communal bull is widespread in some of the areas studied and its lack of immediate availability can be restrictive on efficient fertility.

Median lactation length (Table III.2.4) was not significantly different between the two systems (P>0.05). This result was surprising because farmers with high producing breeds such as Holsteins should see lactation periods considerably beyond the length typical for local cattle. Probably lactation length in the zero grazing herds was limited due to poor feeding and disease. Tawah *et al*, (1998) have already shown that Holstein cows have longer lactation lengths than traditional zebu cows. As the median health cost in zero grazed herds does not seem high (Table II.2.3), the unexpectedly short lactation lengths in the Holsteins may be more a consequence of poor nutrition than poor health, unless health care is not being effectively applied. Recommendations to farmers, based on the poor body condition scoring visually appraised, were given primarily to improve the feeding standards of their cows. Improved feeding, one of the interventions of the project, should increase milk yields, lactation length and reproduction efficiency. The outcome of these interventions should allow a considered assessment of whether pure-bred Holsteins can be managed in this type of zero grazing system in Cameroon to produce milk closer to their potential. Even if they can, there remains interest whether their lifetime productivity – possibly limited due to early death from disease – can match that of indigenous cattle or cross-breeds with Holsteins. It is important that information on mortality rates and longevity in Holsteins are assessed. Only when this has been done can the best advice be given to farmers in Cameroon on the use of pure-bred Holsteins, crosses or better managed selected local cattle for the required increase in national milk production.

The calf production interval in the zero grazed herds (Table III.2.4) was similar to the Saline Zone (15 months) of Bangladesh (Shamsuddin *et al*, 2006). The Economic Opportunity (EO) is relatively low (Table III.2.5.) because the EOS calculation does not take into account any benefit from the effect of a shorter interval between calvings on annual milk production per cow. But of course milk production depends on calving and so small-scale zero grazing dairy farmers recognise the value of striving to get their cows in oestrus and in calf again as soon as possible. Traditional transhumance farmers take a more relaxed and traditional view but education about the potential benefits of more positive reproductive management may be worthwhile. Better fertility efficiency could allow for smaller herd sizes for the same levels of production of both milk and meat. This might reduce pressure on communal grazing areas. Reproductive management was then part of the interventions.

3.2.5.5. Opportunities and interventions

The Participatory Rural Appraisal carried out (Bayemi *et al*, 2005b) before this study showed that, after poor marketing opportunities, inadequate feeding of lactating cows was the second most important constraint on dairy production in Cameroon. This EOS shows that milk production-per-cow is the most important limiting factor in terms of financial return when considering both systems as a whole, followed by lactation length and then age at first calving (Table II.2.5). Economic opportunities for lactation length in the transhumance system are very high because the calculation takes into account the total number of non lactating cows present in the herd. In this parameter non-milking cows contribute to the economic loss of the farmer. The economic opportunity result suggests that Holstein and traditional cows are both exploited below their potential. Milk-production-per-cow could probably be improved by offering more forage to lactating cows. Most zero grazed Holstein cows of this region are undernourished (Bayemi *et al*, 2005b) and restricted cows in zero grazing systems are not usually offered enough forage (Msangi *et al*, 2004). Hay is not common in the region and silage is not produced at all. Therefore farmers cut grass using cutlasses and carry it to the shed. This is time consuming and labour intensive. In this system, concentrate is a supplement and, if not offered especially if free access to forage is limited, lactating cows may be in a severe negative energy balance (Williams, 1990). Such undernourishment is detrimental to production, reproduction and health.

Traditional breeds, if fed more and better digestible forage, will probably produce more milk (Ndambi, 2006). If potential was realized from better feeding, then within-breed selection could be tried to boost the potential for milk production in this system. Transhumance farmers were encouraged to purchase hay. They will be able to afford it if milk marketing is good, which is not presently the case with most farmers of the North West , due to a recent bankruptcy of the main milk plant. Only farmers successful in the informal market are following these recommendations. Milk production per cow can usually be increased by improving the quality of the concentrate supplement. Interventions were planned to do this too.

Constraints brought out by the PRA and EOS led to the setting up of interventions geared towards improving milk sales and milk production per cow. Interventions primarily consisted of advice, education and training, through synchronization of oestrus and AI were carried out by the research team. Most interventions were carried out with the zero grazing herds able to keep good records. These were: 1) Looking at ways to help farmers increase forage consumption by pasture improvement; putting them in contact with hay producers; formulating a new concentrate mixture. 2) Supplementation with concentrates of better yielding zero grazed cows according to stage of lactation. 3) Training farmers in milk processing to cheese and yoghurt in order to improve the shelf life of milk. 4) Linking farmers to better health care services and milk buyers. 5) Introducing artificial insemination using fresh semen (AI). 6) Initiating two milkings a day where appropriate. These interventions were to be applied in an integrated method - any problem faced by a farmer could be addressed, whether it be in the area of marketing, health, management or reproduction.

Transhumance farmers are pastoralists and their herds cannot be easily monitored all year round because of seasonal movements of cattle. They were however encouraged to use AI because they are requesting to have some crossbred Holstein cows. This would be beneficial particularly to women and children because often the cow belongs to the men and the milk to the women. Transhumance farmers were also trained in reproductive management and milk processing.

Partial budgeting is being used to assess the financial benefits of these interventions and to provide evidence to show to other farmers to encourage them to follow suit.

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CHAPTER 4

4. Factors affecting post partum milk production and ovarian activity of small scale dairy cows in the Western Highlands of Cameroon

4.1. Validation of a human progesterone Enzyme Immunoassay (Eia) Kit for use on serum of cattle in Cameroon

Published in Tropical Animal Health and Production

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Validation of a human progesterone EH511 Enzyme Immuno Assay kit for use in cattle serum at Bambui, Cameroon. Tropical Animal Health and Production 39: 335-338.

4.1.1. Abstract

A study aimed at validating a human progesterone enzyme immuno assay kit was carried out on cattle at Bambui, Cameroon. Progesterone ELISA Kits (EH-511) were obtained from Clinpro International. Fourty one cows were selected from of which 19 were pregnant and 22 within 14 days post-partum. Blood samples were analyzed and progesterone levels deduced from a curve obtained from standards absorbance values (A_{450}). Results show that 95.5% of post-partum cows had progesterone levels below 1ng/ml with the highest level being 0.75 ng/ml. The mean level was 0.5±0.26 ng/ml. The cows in the ‘pregnant group’ had progesterone levels ranging from 3.5 to 17.5 ng/ml. This kit can be used for measuring progesterone levels in cattle. Cows with 1ng/ml for two consecutive samples or one sample at or above 3ng/ml are an indication of the presence of corpus luteum while cows below 1ng/ml will be in anoestrus.

Key words: Cameroon, cattle, ELISA, Progesterone

4.1.2. Introduction

Progesterone is a reproductive hormone produced by the Corpus Luteum (CL) of the ovary and the placenta. Its concentration in blood increases in the body after ovulation and during pregnancy and declines during follicular growth after luteolysis and parturition. Its principal sites of production are the ovaries and the placenta during pregnancy. Thus progesterone is commonly measured to determine whether a cow is cycling or pregnant, using Radio Immuno Assay (RIA) or Enzyme Linked Immunosorbent Assay (ELISA) in milk, blood or serum (Plazier, 1993; Ovucheck, 2003).

One of the main constraints hindering dairy cow production in the developing countries is poor reproductive performance of cows (Eduvie *et al*, 1993; Mbaye and Ndiaye, 1993; Makkar, 2002). Although other factors such as health and nutrition also affect reproduction, they usually do this by influencing the functions of the ovaries or uterus, and result in changes of circulating hormone levels. The determination of progesterone (P4) levels to monitor the major reproductive events such as failure or inappropriate oestrus detection, missed heats, early embryonic mortality, and pregnancy estimation gives more accuracy to the evaluation of the reproductive efficiency of dairy farms (Edgerton and Hafs, 1973). Therefore, a common method to assess the reproductive functions of cows has been to monitor progesterone profiles.

In the developing countries, particularly in Cameroon, these methods are not always available. And even when the equipment is even found, the reagents may not be at hand to be able to carry out appropriate tests. Some of the kits developed for humans, when available, could also be used for cattle because progesterone is not species specific (Wakeman, http://www.showdogsupersite.com/kenlclub/breedvet/vfes1.html). EIA has the advantage over RIA of not requiring a radioisotope (Plazier, 1993). Therefore this study aims at validating the use of Human Progesterone Enzyme Immunoa Assay kits (obtained from Clinpro International Co.LLC.) for measuring progesterone in the blood serum of cattle.

4.1.3. Material and methods

4.1.3.1. Animals

Fourty one cows were selected for this study, with 19 being diagnosed and confirmed pregnant by rectal palpation and 22 within two weeks post partum. They were Holstein (*Bos taurus*), Red Fulani (*Bos indicus*) and crossbred (*Bos taurus x Bos indicus*). Holstein cows were kept in stalls and fed in a zero grazing system. Grass was chopped and provided in feeding troughs. Crosses grazed on *Brachiaria spp, Pennisetum purpureum* or *Trypsacum laxum* dominant pastures while Red Fulani cows grazed on communal *Sporobolus africanus* pastures.

Cows were considered pregnant by farmers who declared them bred and did not show external signs of return to oestrus. These pregnancies were subsequently confirmed by rectal palpation. One weekly blood sample was collected for each cow within 2 weeks post-partum.

4.1.3.2. Blood collection and analysis

Blood samples were collected in tubes kept in ice and taken to the laboratory. They were centrifuged at 1200 rpm for 15 mn and the serum stored in a freezer until analysis with the EIA kits obtained from Clinpro International Co. LLC.(Union City, USA, CA 94587, EH-511). It is designed for measurement of total progesterone in human serum or plasma. The minimum detectable level of progesterone in the run comprising post-partum cows was 0.05ng/ml and in the run of pregnant cows was 0.3ng/ml (Clinpro International, 2004 and 2005). Intra-assay precision (coefficient of variation) by replicate determination of four different serum samples in one assay varied from 2.4% to 7.1% while inter assay precision of six different serum samples over a series of individually calibrated assays varied from 2.6% to 12.6%. The assay could detect progesterone levels of up to 50ng/ml above which there is a need of a diluent (but this diluent was not needed as cows will not get that high). The low control had values ranging from 3.5 to 7.5ng/ml and the high control 20 to 39.5ng/ml. Samples, standards and controls were duplicated and the mean absorbance value (A_{450}) calculated in nm. The six standards had the following progesterone concentrations: 0; 0.5; 3; 10; 25 and 50ng/ml. A standard curve was constructed by plotting the mean absorbance for each reference standard against its concentration in ng/ml. This standard graph was used to determine the concentration of progesterone in each sample.

4.1.4. Results and discussion

The assay was considered valid as controls fell within the manufacturer's specified range. The low and high controls had respectively values of 4ng/ml and 34 ng/ml. Twenty one cows out of 22 representing 95.5% of post-partum cows had progesterone levels below 1ng/ml. The mean level was 0.5±0.25. Intra assay precision was 10.4%. Progesterone average level in the 'pregnant group' was 7±4.3 ng/ml with values ranging from 3.5 to 17.5 ng/ml.

These results confirm the normal usage of the tested kit specifying that progesterone concentrations of more than 3ng/ml will be a strong presumptive evidence of the presence of a CL (Clinpro International, 2005) even in cattle. The International Atomic Energy Agency (IAEA) milk standard used in solid phase RIA at Seiberdorf Austria recommended 3nmol/L levels as reflecting luteal phase while less than 1nmol/L were related to anoestrus or follicular phase of the oestrus cycle (Cavestany *et al*, 2001). Progesterone levels in milk reflect those in blood (Ovucheck, 2003). Other studies have demonstrated a strong correlation between EIA and RIA. Plazier (1993) found this correlation to vary from 0.8 to 0.93 while Nagy *et al* (1998) found a correlation of 0.9. The IAEA (1997) also adapted a human progesterone kit to be used in determining P4 in domestic animals including cattle, sheep, goat, buffalo, camelids and yaks. Similarly, Eckersall and Harvey (1987) validated a bovine plasma progesterone ELISA kit to be used in equine, ovine and canine. EIA kits used in one species must be validated for use in other species. Consequently this kit can be confidently used for measuring progesterone levels in cattle. The cow with the highest progesterone level (1.5 ng/ml) in the post-partum group may have had an early return to ovarian activity. Otherwise this could be explained by assay variation. Unfortunately the sample was not reassayed.

This work agrees with the practice that concentrations over 1ng/ml for two consecutive samples or one sample at or above 3ng/ml are an indication of presence of corpus luteum (Cavestany *et al*, 2001; Msangi *et al*, 2004). Owing to the fact that EIA compares very well with RIA provided the assay is carried out by an experienced technician able to standardize each step, the lack of appropriate technicians in developing countries may be a problem if they are not well trained. In which case large differences in duplicate will lead to unacceptable results. This training can even be organized among developing countries as many laboratories are now used with EIA techniques.

Intra assay precision in this work was good (10%). Plazier (1993) stated that intra assay precision in EIA use must be below 15%. Low precision, above this value may happen because of the product not being sufficiently stable during transportation as in the case of long delays in customs clearance. In Cameroon, this kit needs to be ordered from abroad and will be received within a week after shipping. It is sold in the country at $200 per kit and at the Bambui laboratory charged at $10 per sample. Therefore laboratories ordering this kit in Cameroon must ensure quick clearance at the airport and protection from external factors such as high temperatures and exposure to light. Low precision may also be due to a large number of pipetting steps. Laboratories in developing countries will also gain in precision by having mutichannels pipettes of 8 and 12 channels.

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4.2. Post partum ovarian activity and milk production

Paper presented at 3R conference Paris

P. H. Bayemi, D. Cavestany, M. J. Bryant, V. N. Munji, E. C. Webb, M. Ngo Lihep, B. M. A. O. Perera , D. Whitaker, J. N. Mbanya, 2007. Factors affecting return to oestrus and milk production in lactating cows of small holder dairy farms of Bamenda, Cameroon. 3R , Rencontres-Recherche-Ruminants, conference Paris, 14e Journée, Dec 2007. http://www.journees3r.fr/texte.php3?id_article=2553

4.2.1. Abstract

Thirty five pregnant dairy cows were selected for studies on post partum return to ovarian activity and milk production. They consisted of 13 Holstein, 13 local Gudali (*Bos indicus*) and 9 crosses (*Bos taurus x Bos indicus*). Holstein cows were stall fed in a zero grazing system with Guatemala grass *(Trypsacum laxum)*, *Desmodium spp* and Elephant grass (*Pennisetum purpureum*). Concentrate feeding was provided during milking. Crosses and indigenous cattle grazed either on *Brachiaria spp.,* on native *Sporobolus africanus* or on marginal pastures. Monthly records were kept on body condition score (BCS) at calving and milk production from the time of calving to 12 weeks after calving. Blood samples were analyzed using ELISA progesterone kits. Results show that Holstein cows produced more milk than other breeds ($P<0.05$), with an average of 12.52 ± 4.34 litres per cow per day vs 9.59 ± 2.3 for crosses and 3.38 ± 0,94 litres per cow per day for traditional zebu breeds. There was no evidence that parity, system of feeding and calving season affect milk production ($P >0.05$) though primiparous cows produced 13.2± 2 litres per cow per day and multiparous 7.4± 5 litres per cow per day. Milk production was 13.31 ± 4.34 litres per cow per day in the feeding system where cows received more that 3kg concentrate, 8.14 ± 4.49 litres per cow per day and 6.2 ± 3.5 litres per cow per day respectively in feeding systems of less than 3kg concentrate and grazing without concentrate respectively. No factor seemed to influence resumption of ovarian activity ($P>0.05$). The period of post partum first ovulation was 41±2 days in Holstein compared to 38 ±2 days for crosses and 51±20 days for local cows. The mean interval to first service was 58 days. It was found that an increase in one litre of milk production of cows producing between 2 to 20 litres will reduce the anoestrus period by 2.25 days. This finding suggests that in this area, cows producing more milk tend to take less time to resumption to ovarian activity.

Key words: Post partum, oestrus, progesterone, ELISA kits, small holder, dairy, Bamenda, Cameroon.

4.2.2. Introduction

The republic of Cameroon has a population of 6 million cattle of which 4% is dairy (FAO, 2004). More than 90% of this population is found in the northern and northwestern regions. Traditionally, milk production in Cameroon is based mainly on the transhumance system using local zebu cows of the breeds, Gudali, White Fulani, Red Fulani. Quantitatively this production has been low, yielding an average of only 3 liters of milk per cow per day. Subsequent improvement in milk production was made possible through importations of high yielding dairy breeds such as Holstein Friesian, Jersey and others. Although improvements were observed in terms of milk yields in other semi intensive and intensive production systems of 12.8kg per annum per capita (Bayemi *et al*, 2005), milk production has not satisfied the demand and is still below the annual per capita consumption standing currently at 15.3kg.

Reproduction is the key factor affecting the efficiency of production and it is influenced by the environment. Previous studies in the Western Highlands of Cameroon reported an inter-calving period of 448 days in cows whose breed was not stated (Njoya *et al*, 1999). Yet a 12-month calving interval is generally considered the most economically desirable situation for dairy cows (Cavestany *et al*, 2003). An early resumption of the normal post-partum ovarian activity is important in order to maximize reproductive efficiency (Butler and Smith, 1989). It is necessary to have information on the reasons for long periods of resumption of ovarian activity in order to devise interventions aimed at correcting factors that delay reproduction in different breeds. The aim of this research was to study the factors that influence post-partum anoestrus and milk production of cattle breeds used for dairy production in the Western Highlands of Cameroon.

4.2.3. Materials and methods

4.2.3.1. Study site

The North West Region of Cameroon is part of the Western Highlands. It is located in the mid and high altitude zone of the country which lies between latitudes 5°20’ and 7° North and longitude 9°40’ and 11°10’ East of the Equator. The surface area of the Region is 17,910 km^2 covering 1/6 of the country’s land area. Altitudes range from 300 to 3000 m above sea level. There are two main seasons: a dry season from November to mid March and a rainy season from mid March to October. Rainfall ranges between 1300-3000 mm with a mean of 2000 mm. Minimum and maximum temperatures range between 15.50°C and 24.5°C respectively although temperatures can exceed 30°C.

4.2.3.2. Selections of farmers

The farmers who participated in the study were selected by means of the Economic Opportunity Survey (Nordlund *et al*, 2007). Fifteen farmers were chosen on the basis of commitment to long-term collaboration in the present research project. They were from a peri-urban area of Bamenda and had at least one pregnant cow.

4.2.3.3. Animal management

Thirty Five cows were chosen for the study, which consisted of 13 Holstein, 13 local Gudali (*Bos indicus*) and 9 crosses (*Bos taurus x Bos indicus*). Holstein cows were stall fed in a zero grazing system. Forage was cut, chopped and fed to cows in feeding troughs. It consisted mainly of Guatemala grass *(Trypsacum laxum)*, *Desmodium spp* and Elephant grass (*Pennisetum purpureum*). Water was provided daily in iron buckets or in drinking troughs made from iron drums. Concentrate feeding was provided during milking. Crosses and indigenous cattle grazed either on *Brachiaria spp.,* on native *Sporobolus africanus* or on marginal pastures. The feeding systems practiced at those farms were described in order to possibly link reproduction to feeding. This description took into consideration the quantity of concentrate given, the estimated nutrient composition of the feed in terms of crude protein, metabolizable energy, calcium and phosphorus, the type of forage fed, the frequency of feeding, the grazing behaviour and water supply. Three feeding systems were described: Forage without supplementation (A), small level supplementation with forage and at most 2kg supplement (B) and High level supplementation in zero grazing with 3 to 5kg concentrate (C). Monthly records were kept on body condition score (BCS) at calving and milk production from the time of calving to 12 weeks after calving. Milk production was recored daily.

4.2.3.4. Data collection and laboratory analysis

Information such as cow identification, lactation number and breed were obtained prior to the beginning of the study. Pre-partum BCS was recorded using the 1 to 5 scale (Edmonson *et al*, 1989). Daily milk production was recorded after calving. Starting from 7 days after calving, and until 12 weeks, weekly blood samples were collected in 10 ml sample tubes and kept on ice during transportation to the laboratory. They were centrifuged and the serum frozen at -20 degrees Celsius until analysis. Progesterone was analyzed by means of standard ELISA Progesterone kits from Clinpro International Co. LLC.(Union City, USA, CA 94587, EH-511) to determine reinitiation of ovarian activity. This kit has been validated for use in cattle (Bayemi *et al*, 2007). The minimum detectable level of progesterone in the assay was 0.05ng/ml (Clinpro International, 2004). Intra-assay precision varied from 2.4% to 7.1% while inter assay precision varied from 2.6% to 12.6%. The assay could detect progesterone levels of up to 50ng/ml above which there is a need of a diluent. The low control had values ranging from 3.5 to 7.5ng/ml and the high 20 to 39.5ng/ml. Serum samples were analyzed in duplicate.

4.2.3.5. Ovarian activity and milk production

The influence of factors such as age, parity, feeding system, month of calving, breed and body condition score at calving on milk production and ovarian activity was investigated. It was considered that samples with P4 over 3ng/ml or two consecutive samples with more than 1ng/ml indicated ovulation.

4.2.3.6. Statistical analysis

Calving was subdivided into three periods, early (June to July), mid (August to September) and late (October to November) rainy season. The effect of the following factors on milk production and ovarian activity was investigated: feeding system, parity, season of calving, breed, age and body condition score. This analysis used regressions and general linear models procedures (GLM) in SAS.

4.2.4. Results and discussions

4.2.4.1. Milk production

The model tested accounted for 87% of the variation in average daily milk yield. As expected, Holstein cows produced more milk than other breeds and their crosses (P=0.004: Table IV.2.1.). There were individual Holstein cows which produced up to 20 litres per day meaning that even in this small holder system, well managed cows can produce a significant amount of milk. Cows concerned in this study had milk production recorded only for 3 months and cannot efficiently be compared with complete lactation records. The challenge will be for the farmers to strive to maintain good production during the whole lactation. Exotic breeds of Uganda produce 7-10kg per cow per day (ILRI, 1996) over the whole lactation.. In Kenya, a survey found that dairy cows produce 5.9± 4.4 litres per cow per day (Stall *et al*, 2001) while it was 5.5 litres per cow per day in intensive production systems in Tanzania (MOAC, 1998). This higher milk production of the exotic breed in Cameroon may be explained by the fact that cows concerned in this study had been chosen among the small scale farmers accepting to apply technologies aimed at improving their farms. In such, they had started applying these interventions that probably improved their production.

BCS did influence milk production (P=0.002, Table IV.2.1). Although a number of animals was not well fed (BCS < 2), they still managed to produce a substantial amount of milk. BCS is usually well correlated with feeding and was thus expected to have a similar effect. BCS 3 gave less milk because most traditional cows (*Bos indicus*) were in this group.

Table IV.2.1. Effects of different factors on milk production and resumption of ovarian activity

Variables	Factors	Average daily milk production in liters (mean ±std)	Days to first ovulation
Breed	Traditional cows	3 ± 1^a	51 ± 20^a
	Crosses	10 ± 2^b	38 ± 25^a
	Holstein	12 ± 4^c	41 ± 24^a
Body Condition Score	2	13 ± 2^a	38 ± 12^a
	3	6 ± 3^b	48 ± 26^a
	3.5	15 ± 3^a	23 ± 8^a
Season of calving	Early rainy	9 ± 5^a	51 ± 20^a
	Mid rainy	7 ± 5^a	41 ± 24^a
	Late rainy	10 ± 5^a	38 ± 25^a
Feeding	Grazing	8 ± 5^a	41 ± 24^a
	less than 3kg concentrate	6 ± 4^a	51 ± 26^a
	More than 3kg concentrate	13 ± 5^a	31 ± 12^a
Parity	Primiparous	8 ± 6^a	43 ± 23^a
	Multiparous	9 ± 4^a	40 ± 24^a

[a, b] Means of the same variable with the same superscript are not significantly different

There was no evidence that period of calving, parity and system of feeding influence milk production (P>0.05) although as expected feeding system C with more concentrate seemed to lead to more milk production. Sawadogoo et *al* (1999) in Senegal rather found a difference in feeding systems. In this zero grazing system where restricted cows are undernourished because they do not receive enough forage, supplementation will help them to receive more energy and therefore produce more milk. However farmers tend to neglect the forage feeding of zero grazing cows and therefore this group does not produce as much milk as expected.

4.2.4.2. Post partum ovarian activity

There was no evidence that any factor studied in this work had an influence on post-partum ovarian activity (P>0.05). However, the interval to the first post-partum ovulation seemed shorter in Holstein and crosses compared to traditional cows (Figures 4.2.1, 4.2.2 and 4.2.3). The fact that traditional cows did not take a very long time to return to ovarian activity is an indication that they are well adapted to this challenging environment.

The post-partum anoestrus period in this study is shorter compared to that reported by Cavestany *et al*, (2001) of 80.8±8.6 days in Holstein and 104.8±7.6 days in crosses. It is also shorter than that found by Msangi *et al* (2004) in crossbred cows of Tanzania (74±33 days). Furthermore, Njoya *et al* (1999) found the period to be 172 ± 16 days in local cows of the Western Highlands of Cameroon. Approximately 20% of cows returned to ovarian activity within 30 days post-partum and 42.8% between 30 and 60 days post partum. The interval from calving to first service in cows which had an early first ovulation was nearly half compared to those with a later first ovulation (Table IV.2.2). This is an indication that early P4 rise results in early service.

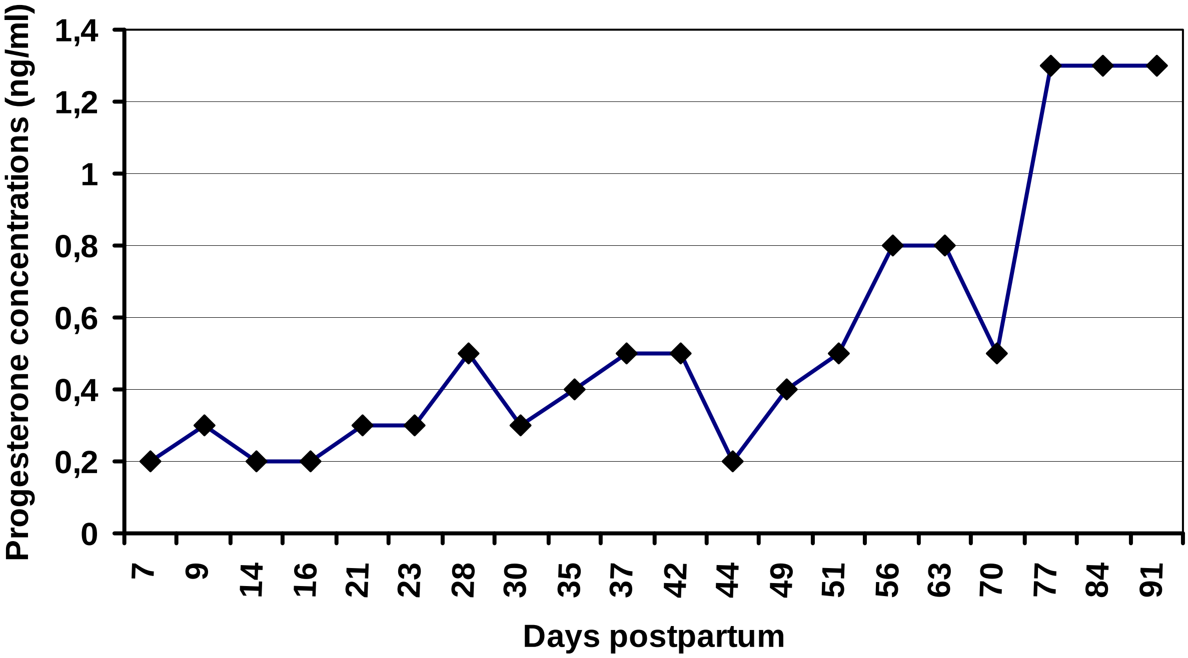

Figure 4.2.1. Progesterone profile of a local cow showing a long interval to the first post partum ovulation

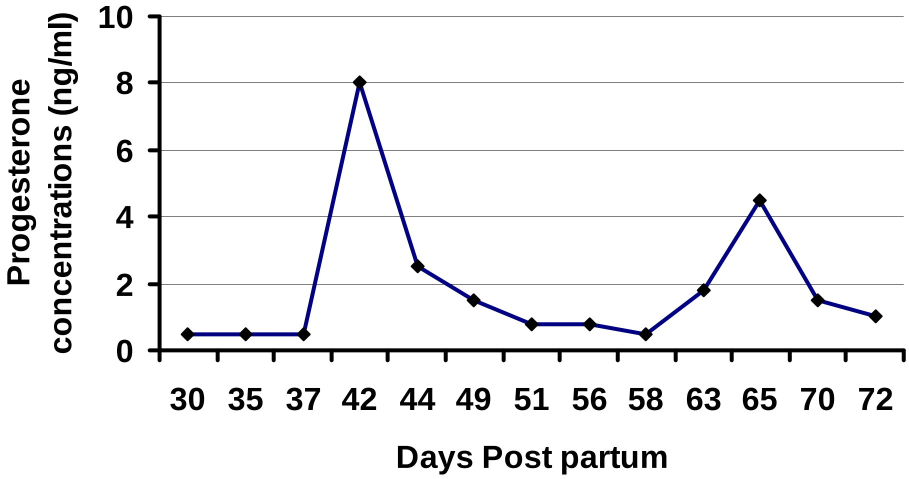

Figure 4.2.2. Progesterone levels of a Holstein x Gudali cross (one short cycle followed by cessation of ovarian activity and another short cycle)

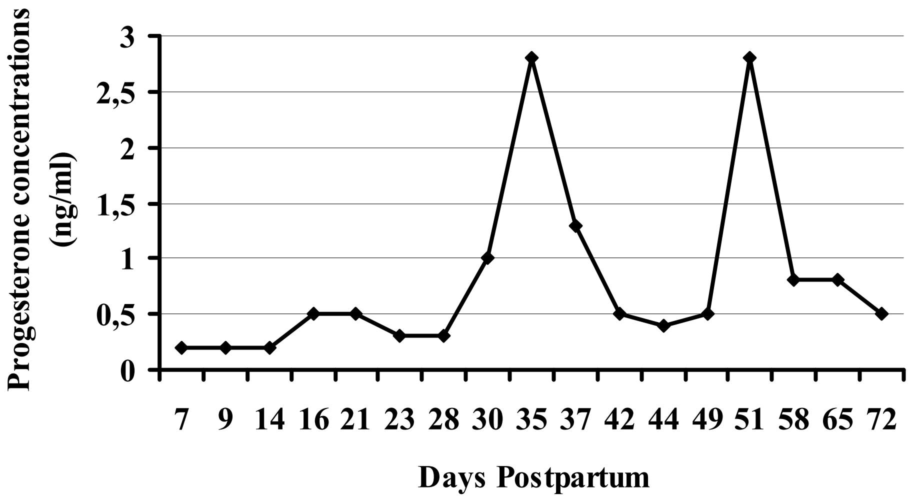

Figure 4.2.3: Progesterone levels of a Holstein cow showing early resumption of post partum ovarian activity

Table IV.2.2. Interval from calving to first P4 rise and first service

	Early return **(1st P4 before 30 days)**	**Late return** **(1st P4 rise after 30 days)**
Calving to 1st P4 rise (days)	23.66 ± 5.4	53.11± 19.87
Calving to 1st service (days)	41.33 ± 12.81	70.75 ± 24.52

There was no evidence that feeding systems in this study influenced the return to ovarian activity ($P>0.05$). However, cows in system C showed a shorter post-partum anoestrus period (Figure 4.2.4). These results are similar to those of Nkya *et al* (1999) in Tanzania who found no effect of supplementation on post-partum return to ovarian activity though animals receiving more concentrate showed a slightly shorter post-partum anoestrus period.

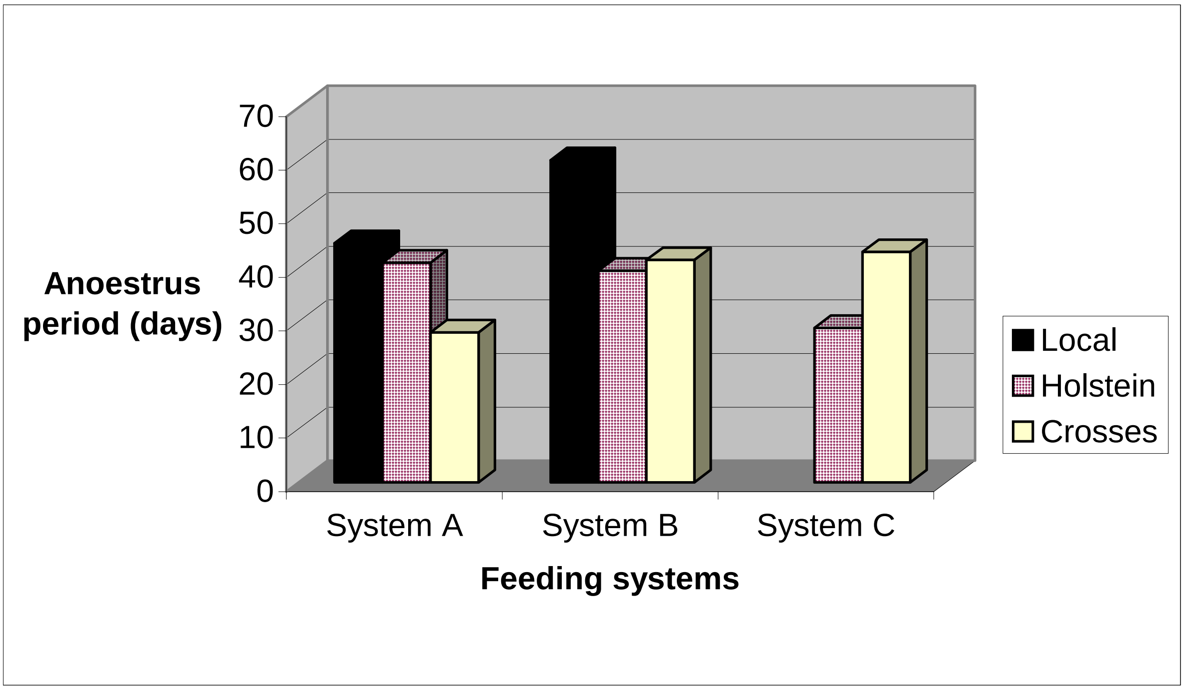

Figure 4.2.4. Effect of feeding systems on ovarian activity

The relationship between milk production and post partum ovarian activity was investigated. It was found that interval to first ovulation could be predicted by milk production ($P < 0.05$). An increase in one litre of milk production of cows producing between 2 to 20 litres will reduce the anoestrus period by 2.25 days. This finding suggests that in this area, cows producing more milk tend to take less time to resume ovarian activity, which agrees with the findings of Dhaliwal *et al* (1997) and Cavestany *et al* (2001) who reported that cows producing less milk have a prolonged anoestrus. There is a cumulative gain in well managed cows which produce more milk and resume reproductive activities earlier. However below a threshold weight, the cows are expected to show a delay in the rate at which they returned to oestrus because of being in a negative energy balance (Butler, 2000).

In conclusion, this study indicates that even though Holstein cows are not managed to their full potential, they are still better than local cows in terms of milk production and reproductive efficiency under the zero grazing system practiced in this region of Cameroon.

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4.3. Effect of pre-partum feed supplementation on post partum ovarian activity, milk production and calf growth of dairy cattle of small scale dairy systems of the Western Highlands of Cameroon

Accepted in TECDOC, International Atomic Energy Agency (IAEA), Vienna, Austria.

Bayemi, P. H., Webb, E. C. , Mbanya, J. N., Cavestany, D. , Bryant, M. J. and Nsongka, V. M., 2008. Effect of short term Pre-partum Feed Supplementation on Post Partum Ovarian Activity, Milk Production and Calf Growth of Dairy Cattle of small scale dairy systems of the Western Highlands of Cameroon. Accepted in TECDOC, small scale market oriented dairy systems, International Atomic Energy Agency (IAEA), Vienna, Austria.

4.3.1. Abstract

Thirty seven cows were selected for an on-farm study on the effect of feed supplementation before calving on milk production, ovarian activity and calf growth of Holstein, indigenous Red Fulani cows and their crosses. Pre-partum feed supplementation, 30 days before calving, was done using cotton seed cake (80%), maize (18%), bone meal (1%) and kitchen salt (1% NaCl). Supplementation levels consisted of a LOW supplementation fed at 1kg per animal per day and HIGH supplementation fed at 2kg per animal per day. In addition, Red Fulani cows received the supplements in two different ways namely a pre-partum supplementation consisting of 1kg per cow per day and pre-and post-partum supplementation consisting of 1kg per cow per day before calving and 1kg per cow per day post partum up to 30 days after calving. Blood samples were analyzed using ELISA Progesterone kits to determine the length of post-partum anoestrus. Results show that pre-partum levels of feeding did not have any effect (P>0.05) on body condition score (BCS) at 12 weeks after calving, calf birth weight, average daily weight gain of calves, milk production and resumption of ovarian activity. High BCS at calving was shown to influence BCS at 12 weeks of lactation. Holstein cows had bigger calves (P<0.01) at birth (45kg) compared to traditional cows (36kg) and crosses (34kg). There was little benefit of pre-partum supplementation on the parameters investigated in this study.

Key words: Cameroon, small holder dairy, pre-partum supplementation, post-partum

4.3.2. Introduction

Supplementation with concentrates is a key aspect to improve productivity in tropical dairy production. Not only does supplementation help sustain high milk yields of cows, but it also improves the fertility of these cows (Mukasa-Mugerwa, 1989). In developing countries, low income farmers do not always supplement milking cows, yet they expect them to produce adequate quantities of milk and also complete involution and return to the reproductive phase in the shortest possible time. Most farmers who supplement their cows do so by giving a small quantity of concentrate during milking. Studies have shown that cows have a critical body condition score at mating, below which conception rates are reduced if the animals are still in a negative energy balance (Haresign, 1980). The energy status of the cow, seen by the change in the body condition score, also affects fertility (Chamberlain and Wilkinson, 1996). These studies were carried out in high yielding cows in commercial farms. There is little information on the effect of pre-partum supplementation and body condition score at calving on production parameters in small holder dairy systems. The purpose of this study was to investigate the effects of pre-partum supplementation, breed and body condition score on the resumption of ovarian activity, milk production and calf growth of milking cows in small holder dairy systems in Cameroon.

4.3.3 Materials and methods

4.3.3.1. Study site

The North West Region of Cameroon is located in the mid and high altitude zone of the country, which lies between latitudes 5°20' and 7° north and longitude 9°40' and 11°10' east. The surface area of the is 17,910 km2 covering 1/6th of the country's land area. Altitudes range from 300 to 3000 m above sea level. There are two main seasons: a dry season from November to mid-March and a rainy season from mid-March to October. Rainfall ranges between 1300-3000 mm, with a mean of 2000 mm. Minimum and maximum temperatures range between 15.50°C and 24.5°C, respectively, although temperatures above 30°C are not uncommon.

4.3.3.2. Animals and experimental design

Thirty seven cows from 24 farms were randomly selected from dairy farms in the region. They were bred by natural mating and confirmed pregnant by rectal palpation at about 6-8 months of gestation. The experimental animals consisted of 26 Red Fulani (*Bos indicus*), 28 Holstein (*Bos taurus*) and 18 crosses (*Bos taurus x Bos indicus*). The potential effects of diffences in forage availability were assumed to be reflected in the body condition score of cows.

Holstein cows were stall fed in a zero grazing system. Forage was cut, chopped and fed to cows in feeding troughs. This forage consisted mainly of Guatemala grass (*Trypsacum laxum*), *Desmodium spp* and Elephant grass (*Pennisetum purpureum*). Crosses and indigenous cattle grazed either on *Brachiaria spp.,* on native *Sporobolus africanus* or on marginal pastures. The supplement (340 g/kg crude protein and energy level of 11MJ/kg) consisted of cotton seed cake (80%), maize (18%), bone meal (1%) and kitchen salt (1% NaCl). Holstein and crosses were randomly allocated to a 2 × 2 factorial design, breed x level of feeding.

Supplementation levels consisted of a LOW fed at 1kg per animal per day and HIGH fed at 2kg per animal per day (T1 to T4). Red Fulani cows were fed in two different ways, namely, pre-partum supplementation consisting of 1kg per cow per day (T5) and pre-and post-partum supplementation consisting of 1kg per cow per day before calving and 1kg per cow per day post partum up to 30 days after calving (T6). The supplement for this last period was given during milking, whereas for other groups the supplement was given in the morning from 30 days before the expected calving date until calving (Figure 4.3.1). When a cow calved after the expected day, it did not receive any additional supplement other than the 30 or 60kg planned. And when it calved before the expected day, experimental supplementation stopped. Some farmers in the zero grazing and semi-extensive systems continued to supplement their cows after calving. This variable was included in the statistical analysis. Information such as cow identification, lactation number and breed were obtained prior to the beginning of the study. Body condition scores (BCS) were done using the 1 to 5 scale (Edmonson *et al,* 1989). Daily milk production, calf birth weight and weekly weight of calves were recorded after calving. Red Fulani cows were not milked and so their milk production is not considered in the study. But calf weight was noted in order to have an idea of milk production at the early age; furthermore it is expected that this supplementation influences early ovulation.

4.3.3.3. Progesterone levels analysis

Starting from 4 days post-partum until 12 weeks post-partum, weekly blood samples were collected in 10 ml sample tubes and kept on ice during transportation to the laboratory. Blood samples were centrifuged and the serum frozen at -20 degrees Celsius until analyzed. Progesterone was analyzed by means of standard ELISA progesterone kits from Clinpro International Co. LLC. (Union City, USA, CA 94587, EH-511) to determine re-initiation of ovarian activity. The minimum detectable level of progesterone in the assay was 0.05 ng/ml (Clinpro International, 2005). Intra-assay precision varied from 2.4% to 7.1% while inter-assay precision varied from 2.6% to 12.6%. The assay could detect progesterone levels of up to 50 ng/ml, above which a diluent is required. The low control had values ranging from 3.5 to 7.5 ng/ml and the high 20 to 39.5 ng/ml.

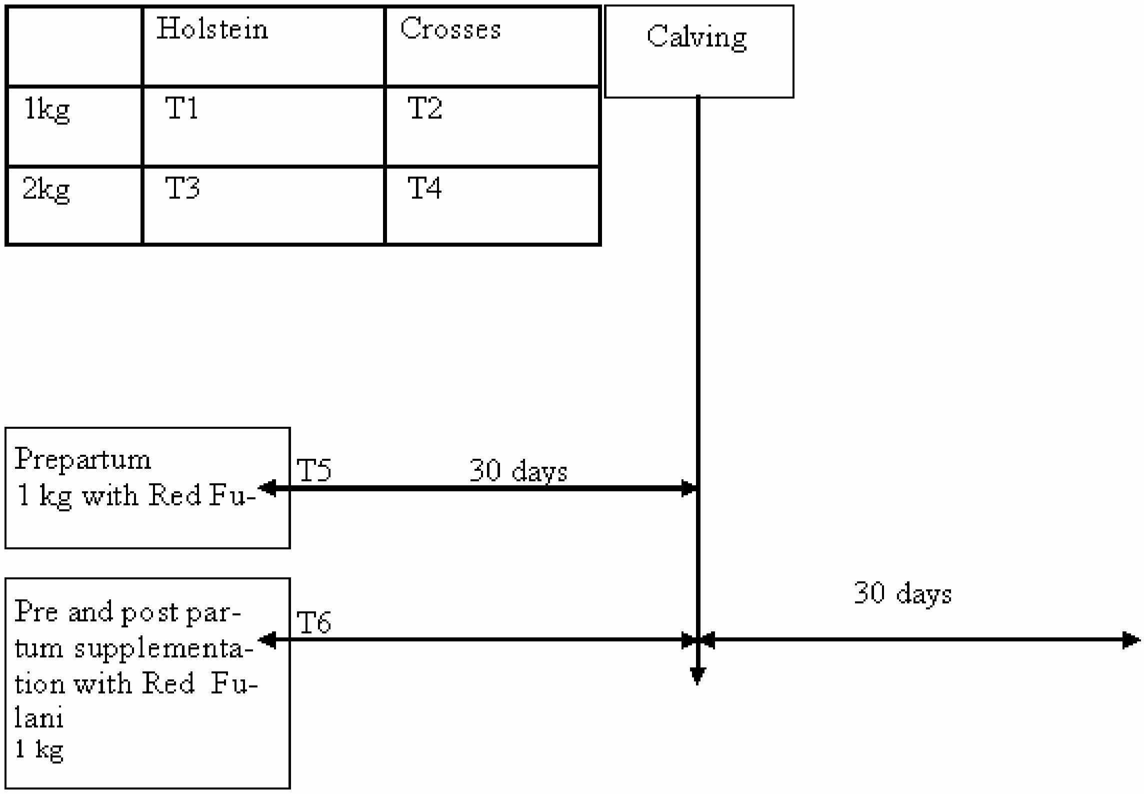

Figure 4.3.1. Diagrammatic representation of the six experimental treatments

4.3.3.4. Statistical analysis

A General Linear Model (GLM) in SAS was used to test the effect of the four variables listed below on calf birth weight, average daily weight gain of calves up to 12 weeks of age, milk yield within the same period, days required to resumption of ovarian activity and body condition score of milking cows at 12 weeks post partum. The variables included in the model were: level of pre-partum feeding, body condition score at calving, breed and post-partum supplementation. Body condition score at calving was divided into two groups: less that 3 and from 3 upwards. Post-partum level of feeding was also considered in two groups: ≤3kg per cow per day and >3kg per cow per day, up to a maximum of 6kg per cow per day.

Within breed comparison of the effect of the level of feeding on the variables studied was done. Means were compared using the Student-Newman-Keuls Test. The statistical models were as follows:

$^{\gamma}{}_{ijkl} = \mu + F_i + B_j + C_k + S_l + e_{ijkl}$, Where $^{\gamma}{}_{ijkl}$ is the dependant variable (milk yield, daily weight gain of calves, length of post-partum anoestrus and body condition score at 12 weeks post-partum). μ is the overall mean, F_i is the level of pre-partum feeding, B_j is the cow breed, C_k is the body condition score at calving, S_l is level of post-partum supplementation and e_{ijkl} is the random error.

$^{\gamma}{}_{ijk} = \mu + F_i + B_j + C_k + e_{ijk}$, Where $^{\gamma}{}_{ijkl}$ is the calf birth weight, μ is the overall mean, F_i is the level of pre-partum feeding, B_j is the cow breed, and C_k is the body condition score at calving, e_{ijk} is the random error.

For the Red Fulani, $^{\gamma}{}_{ijk} = \mu + F_i + B_j + C_k + e_{ijk}$, F_i is the level of feeding either prepartum or throughout up to 12 weeks, B_j is the cow breed, and C_k is the body condition score at calving, e_{ijk} is the random error.

4.3.4. Results

Results show that there was no significant effect (P>0.05) of pre-partum level of feeding on the variables studied in this experiment, (Table IV.3.1). Similarly the birth weights of calves were slightly higher when cows were fed more concentrates before calving, although this result was not statistically significant (P>0.05). The results confirm that BCS at calving significantly influenced BCS at 12 weeks after calving (P=0.014). Cows in a better body condition managed to maintain their condition (BCS at 12 weeks) more stable during the period of investigation (Table IV.3.2). The condition score at calving did not affect the other variables as expected in this study (P>0.05).

Breed significantly influenced (P < 0.001) calf birth weights, although crosses did not have significantly higher birth weights than traditional breeds (Table IV.3.3). Average daily weight gains of calves were slightly higher for the Holstein breed. Traditional cows suckled their calves and as such, they were not milked. Furthermore, it was found that their return to ovarian activity was similar to the other breeds (P>0.05).

On the other hand, there was no evidence (P> 0.05) that post-partum supplementation had any influence on BCS at 12 weeks post partum, average daily weight gain of calves, milk yield or time required to post-partum return to ovarian activity (Table IV.3.4). However there were indications that high levels of concentrate feeding of lactating cows let to marginally higher weight gains of calves (P=0.08). Supplementation of newly calved cows tended to increase milk production although this was not statistically significant (P> 0.05). This result was to be expected, because supplementation is supposed to help the cow get more nutrients not found in pastures.

Table IV.3.1. Effect (lsmeans±sem) of pre-partum level of feeding on BCS, calf weight, weight gain, milk production and ovarian activity

	BCS at 12 weeks	Calf birth weight (kg)	Average daily weight gain (g)	Average daily milk production (litres)	Postpartum resumption of ovarian activity (days)
Low Level of feeding (n=10)	2.6±1.42[a]	37±1.4[a]	124±14[a]	8.3±1.6[a]	79±13[a]
High Level of feeding (n=9)	2.3±1.38[a]	40±1.4[a]	91±19[a]	8.1±1.5[a]	70±15[a]

[a] Means with the same letter are not significantly different.

Table IV.3.2: Effect (lsmeans±sem) of body condition score at calving on BCS at 12 weeks calf weight, weight gain, milk production and ovarian activity

	BCS at 12 weeks	Calf birth weight (kg)	Average daily weight gain (g)	Average daily milk production (litres)	Postpartum resumption of ovarian activity (days)
BCS <3 (n=9)	2.4±0.16[a]	38±1.3[a]	105±14[a]	8.9±1.2[a]	69±11[a]
BCS>3 (n=10)	2.9±0.19[b]	40±1.6[a]	110±19[a]	8.7±1.5[a]	68±13[a]

[a,b] Means with the same letter are not significantly different.

Table IV.3.3. Effect (lsmeans±sem) of breed on cow and calf production and reproductive performances

	BCS at 12 weeks	Calf birth weight (kg)	Average daily weight gain (g)	Average daily milk production (litres)	Postpartum resumption of ovarian activity (days)
Traditional (n=7)	2.9±0.4[a]	36±1.7[a]	106±39[a]	Not milked	76±12[a]
Holstein (n=10)	2.3±0.13[a]	45±1.6[b]	134±12[a]	12±0.9[a]	55±9[a]
Crosses (n=2)	2.8±0.18[a]	34±1.9[a]	83±17[a]	9±1[b]	56±9[a]

[a] Means with the same letter are not significantly different.

Table IV.3.4. Effect (lsmeans±sem) of post partum supplementation on BCS, calf weight gain, milk production and post-partum ovarian activity

	BCS at 12 weeks	Average daily weight gain (g)	Average daily milk production (litres)	Postpartum resumption of ovarian activity (days)
< 3kg (n=10)	2.5±0.15[a]	106±14[a]	7±0.8[a]	61±6[a]
3 to 6kg (n=9)	2.9±0.24[a]	109±23[a]	9±1.2[a]	64±11[a]

[a] Means with the same letter are not significantly different.

In order to investigate the variability within breeds, analyses similar to the ones above were done within each breed to investigate the effect of the level of feeding on the variables considered in this work. The results were not different compared to the between breed comparisons.

4.3.5. Discussion

Condition score is related to the level of feeding. In this experiment, BSC at calving did not affect return to ovarian activity. This result agrees with that reported by Bourchier *et al* (1987) who showed that condition score at calving did not affect conception rates and therefore resumption of ovarian activity until condition score was below 1.5. This level of BSC was not observed for the cows in the present study. Although not significant, there were indications that cows with greater BCS at calving produced less milk. Cavestany *et al* (2003) showed a negative correlation between BCS and milk production. However BCS at calving strongly influenced BCS at 12 weeks lactation. Stalker *et al* (2006) also found that feeding supplement pre-partum improved BCS precalving and prebreeding and increased the percentage of live calves at weaning. These results indicates that within the last third of gestation, cows should be fed adequately in order to ensure a sound BCS at calving which correlates with a good nutritional state of the animal even after calving.

The effect of supplementation before calving yielded no additional improvements. However, logic would suggest that feeding some supplement before calving will help the cow to increase forage digestibility and therefore feed efficiency especially with low quality feeds commonly found in the tropics. Perhaps one explanation for a lack of observed effect was the relatively small difference between treatments. It seems that it would have been better to have levels of 0kg and 2kg, rather than 1kg and 2kg. That would have possibly increased the chance of observing an effect. But farmers were not willing to participate as a 0kg control as they would have gained nothing from the experiment. Farmers regarded participation in the experiment as a way to get concentrates for free and would not have adhered to an experimental design with 0kg concentrate.

Chamberlain *et al* (1996) suggest that 10 days before calving, the cows should be put on a diet similar to that for the medium-yielding cows in the milking herd, as two weeks before and two weeks after calving are the most important of the productive cycle. Holstein cattle have a large frame and they generally produce bigger calves even in challenging environments. Although the birth weights of calves are not expected to be as high as in their original region, they still outweigh traditional Cameroonian breeds and their crosses. No evidence of heterosis was observed in birth weights, as crossbred animals had lighter weight offspring than did local animals. This may be because these crosses are not from the F1 generation. Also, the breed of sire was not considered in the analysis and perhaps indigenous animals were carrying a greater proportion of calves sired by Holsteins. The small difference in birth weights may show that these can adequately be used in crossing with the Holstein breed without fear of an increasing problem of calving difficulties.

Traditional cows were not milked. They were therefore able to suckle their young as naturally as possible. Their production was therefore not recorded. Meanwhile crossbred cows, although they grazed, were partially milked. Their calves could not receive enough quantities of milk and tended to show lower weight gains. It is worth mentioning that Holstein calves were bucket fed and their weight gains will not adequately reflect milk production of their mothers but milk offered by the farmers. As such, average daily weight gains of calves will not adequately reflect the effect of treatments.

Post-partum supplementation in *Bos indicus* Red Fulani cows, as expected, tended to lead to higher weight gain of calves and therefore, higher milk production as early calf weight was assumed to be reflective of mother's milk production. But in this study the tendency was not significant ($P>0.05$). Stalker *et al* (2006) also found that calves born to dams fed supplement pre-partum had similar birth weight but greater weaning weight.

The overall mean length of post-partum anoestrus was 64 days. However 25% of cows showed a persistent high progesterone concentrations. This is an indication of infections and it shows the need for veterinary intervention for many cows in these systems. Post-partum anoestrus was lower in this study compared to the work of Msangi *et al* (2004) with Low supplementation leading to a period of 110±9 days and High supplementation 87±7.6 days. Similar results were reported by Cavestany *et al* (2003) with Holstein cows (49.9±7.1days). Fagan and Roche (1984) found an early resumption of ovarian activity in Holstein cows in a pasture based production system.

Though there is evidence that good pre-partum nutrition shortens the length of post-partum anoestrus (Selk *et al*, 1988; Wright *et al*, 1992), there are also conflicting reports which may be reflected in the interactions among pre- and post-partum nutrition, negative energy balance, BCS, milk yield and suckling, as well as other environmental factors that influence duration of post-partum anestrus (Montiel and Ahuja, 2005). Therfore, post-partum resumption of ovarian activity may not depend exclusively on BCS at calving but on other factors such as BCS post-partum and health status. Wiltbank *et al* (1964) found that breeding cows must be in an improving body condition during the breeding period. This was confirmed by Wiltbank (1977) and Haresign (1984). Animals losing weight between calving and breeding usually have decreased conception rates (Anon, 1984). Therefore, adequate feeding at the early stage of lactation is crucial even in small-scale dairying.

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CHAPTER 5

5. Cattle health

5.1. Prevalence of *Brucella abortus* antibodies in serum of Holstein cattle in Cameroon

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Bayemi, P. H., Webb, E. C., Unger, H., Nsongka M. V., Njakoi, H. , 2008. Prevalence of *Brucella abortus* antibodies in serum of Holstein cattle in Cameroon. Tropical Animal Health and Production. 41, Issue2, pp 141-144.

5.1.1. Abstract

Holstein cattle (298) of a small scale dairy production systems were screened for *Brucella abortus* antibodies in 21 villages in the Western Highlands of Cameroon by ELISA. The screening was done using Brucella-Ab C-ELISA kit. Age of animals was divided into the following groups: less than one year, one to less than three years, three to five years and more than five years. The Chi-square analysis in SAS was used to test differences of *Brucella* prevalence amongst age groups, sex and locations. Results show a general seroprevalence of 8.4%. The rate of brucellosis infection was higher in females compared to males (P= 0.0143) considering the whole population tested. But when camparison was done relative to each sex, results were similar. Of the 192 cows tested, 14 were infected giving a within-sex seroprevalence of 7.3% while 6/74 bulls were infected with a seroprevalence of 8% (some positive animals had no labelled sex). There was no evidence (P=0.11) of difference in the seroprevalence of age groups although animals above one year and below three years accounted for nearly half of the infected animals. 64% of infected animals were found in three locations (P=0.015): Kutaba (32%), Bamendankwe (16%) and Finge (16%). A specific control programme should be organized in these locations and an effort should be made to determine the causes of the spread of the infection. Owing to the fact that animals screened are from the high milk yielding Holstein breed, it is recommended that measures should be taken to ensure the eradication of the disease within the population and sound control measures adopted to avoid a further spread of the disease to larger cattle populations in the region. Infected animals should be slaughtered systematically. All farmers should be advised to boil milk before consumption. Vaccination against *Brucella abortus* and regular *Brucella* testing should be instituted.

Key words: *Brucella*, Cameroon, ELISA, Holstein, small scale dairy

5.1.2. Introduction

Brucellosis is a major zoonosis that occurs worldwide. It is caused by small nonmotile coccobacilli of the genus *Brucella*. Although the reported incidence and prevalence of the disease vary widely from country to country, bovine brucellosis caused mainly by *B. abortus* is still the most widespread form. Even though many countries have tried to eradicate *B. abortus* from cattle, it appears that bovine *B. melitensis* infection is emerging as an increasingly serious public health problem. Although it is anticipated that brucellosis is present in the major animal producing areas, the current status of brucellosis in Cameroon is not clear and it is becoming a major concern to veterinarians and physicians alike. According to OIE, official measures are in place in Cameroon to control bovine brucellosis through movement control of cattle at the borders and within the country but since 1996 no outbreaks have been reported to OIE. This however is not indicative of the absence of the disease but rather of an underestimation of the brucellosis in Cameroon (Shey-Njila *et al*, 2005).

Peri-urban small scale dairy farms in the Western Highlands of Cameroon use Holstein cows in a zero grazing system. The milk produced is home consumed, sold in informal markets or collected by a processing plant. However, the health status of this milk is unknown. There is a need to assess its quality in terms of health hazards and ensure the safety of consumers. The main objectives of this work therefore were to carry out a sero-epidemiology of Holstein cattle in the Western Highlands in order to establish their brucellosis status, create public awareness of the epidemiology of brucellosis in Cameroon and make concrete proposals to the appropriate authorities for adequate control measures to be put in place.

5.1.3. Materials and methods

298 Holstein cattle were screened from 21 locations representative of villages where purebred Holstein cows are kept. However, only 266 animals were fit for the analysis. Cows used in the Heifer International Cameroon scheme are quite separated from each other because farms are isolated. These animals were not vaccinated against *Brucella*. Age was divided into the following groups: less than one year, one to less than three years, three to five years and more than five years. Blood samples were collected within two weeks in June 2006. The samples were immediately put on ice. At the laboratory, the samples were centrifuged at 1500 rpm for 15 min and the serum kept in a freezer until the day of analysis.

5.1.3.1. Principle of the test

The screening was done using Brucella-Ab C-ELISA kit (SVANOVA, Sweden, 2005). The competitive Enzyme Linked Immunosorbent Assay (C-ELISA) for detection of serum antibodies to *Brucella abortus* and *melitensis* is a multi-species assay allowing detection of *Brucella* specific antibodies in both domestic and wildlife species. In cattle, this assay can distinguish between *Brucella* infected animals, *Brucella* strain 19 vaccinated and animals infected with cross-reacting gram-negative bacteria. Briefly, the samples are exposed to *Brucella abortus* smooth lipopolysaccaride (S-LPS) coated wells on microtiter plates together with a mouse monoclonal antibody (mAb) specific for an epitope on the o-polysaccharide portion of the S-LPS antigen. After an incubation period the microplate is washed and goat anti-mouse IgG antibody conjugate with horseradish peroxidase is added which binds to the mAb's. Unbound materials are removed by rinsing before the addition of substrate solution. The chromogen tetramethyl-benzidine with H2O2 as substrate leads to a colour change which is read within 15 minutes with an ELISA reader at 450nm. Samples were tested in duplicates.

5.1.3.2. Statistical analysis

The Chi-square analysis in SAS was used to test differences of *Brucella* prevalence amongst age groups, sex and locations.

5.1.4. Results and discussion

Results suggest that the rate of brucellosis infection was higher in females compared to males (P= 0.0143) considering the whole population tested. But when camparison was done relative to each sex, results were similar. Of the 192 cows tested, 14 were infected giving a within-sex seroprevalence of 7.3% while 6/74 bulls were infected with a seroprevalence of 8%. In Nigeria, Ocholi et al (1996) also found no difference between sexes although the overall seroprevalence was 6.6%. There was no evidence (P=0.11) of differences in seroprevalence of different age groups although animals above one year and below three years accounted for nearly half of the infected animals Table V.1.1.

Results obtained in this study show a seroprevalence of bovine brucellosis of 8.4% in the sera tested. This prevalence is within 4.88 to 9.64% reported by Shey-Njila in 2004 in a survey conducted at the abattoir of Dschang, Cameroon. Similarly, the samples collected at the abattoir of Yaounde in Cameroon, indicated a seroprevalence of bovine brucellosis of between 7.2 and 8.8% (Shey-Njila *et al*, 2005). These authors said that brucellosis was still enzootic in zebu cattle in areas where the cattle came from. Already in 1986 a survey carried out at the Institute of Animal Research at Bambui, Cameroon showed a prevalence of over 20% in cattle reared at ranches and 4% in those from traditional systems (IRZ, 1985 and 1986). In the northern part of Cameroon, Bornarel *et al* (1987) found a brucellosis seroprevalence of 12.5%. Several other studies reported seroprevalences ranging from 7 to 31% (Domenech *et al,* 1980, 1982a, 1982b, 1985; Bornarel *et al*, 1987, Akakpo *et al*, 1987). Lefèvre (1991) concluded that in Cameroon, the prevalence of bovine brucellosis exceeds 5%

In neighbouring Tchad *Brucella* seroprevalence was found to be 7% (Schelling *et al*, 2003) while in Mali the prevalence was 22% (Tounkara, 1994).

Animals selected for this work were Holstein cows in an intensive system. The *Brucella* seroprevalence in this population was similar to other reports on brucellosis in Cameroon. In Eritrea, Omer *et al* (2000) also found that 8.2% of cattle infected with *Brucella* were kept in an intensive system. Cows used in the Heifer International Cameroon scheme are quite separated from each other since the farms are quite isolated. But it may be possible that milk used to feed calves in an infected herd could be sold to other dairy farmers for the feeding of calves. Otherwise, it could be possible that proximity with other farm animals (sheep, goats, dogs and pigs) serves as reservoirs for these herds. It will be interesting then to also screen the prevalence of *Brucella* in other farm animals. Furthermore the 'passing-on-the-gift' scheme used in this Non-governmental Organization, whereby farmers receiving a Heifer pay-back with another heifer which will be given to another farmer may also contribute to spreading the infection. In case a cow is infected, the heifer calf will carry the infection to the neighbouring farm. A proportion of animals may also have been infected because of the common bull scheme whereby farmers take cows for breeding to the village bull although in this study, mature breeding bulls were not infected.

Table V.1: Frequency and percentage of infected animals by age groups

Age (years)	**Sex**	**Frequency (Infected/Tested)**
≤ 1	Females	1/9
	Males	2/13
1 and ≤ 3	Females	4/51
	Males	4/36
3 and ≤ 5	Females	6/56
	Males	0/20
>5	Females	3/76
	Males	0/5

NB 32 Animals did not have any labelled sex and 3 of such animals were infected.

The study also showed that *Brucella* infection varied with location (P=0.015) with 3 out of 21 locations accounting for 64% percent of infected animals namely Kutaba (32%), Bamendankwe (16%) and Finge (16%). These results indicate that a specific control programme should be organized at these locations. Schelling *et al*, (2003) working in Tchad found that 3.8% of people working with livestock were infected with *Brucella*. This is an alarmingly high value which emphasizes that the dairy farmers selected for this study should take special measures to avoid infection by *Brucella*.

It is recommended that measures should be taken to ensure the eradication of the disease within the population and a sound testing and control system instituted to prevent the further spread of the disease to the larger cattle populations in the zone. 1) All farmers should be advised to boil milk before consumption. 2) Another test should be done to confirm positive animals, after which all infected animals should be slaughtered. 3) Care should be taken in areas of high prevalence to determined the possible causes of the spread of the infection. 4) Vaccination against *Brucella* should be instituted. This will be done every three years for the same animals as the vaccine lasts for that period of time. The vaccinated animals should be ear tagged or marked. However, care should be taken not to vaccinate pregnant animals. 5) To ensure a sound population of Holstein cows within the HPI scheme, this ELISA test should be repeated yearly since it is a more sensitive test compared to the Rose Bengal, standard agglutination and Coombs test in the diagnosis of brucellosis (Saz *et al*, 1987). 6) Artificial insemination with healthy semen should be imperative for the Heifer International scheme to avoid contamination of these valuable animals from infected bulls.

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CHAPTER 6

6. Impact of management interventions in small-scale dairy farms of the Western Highlands of Cameroon

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6.1. Abstract

A study was carried out to evaluate the impact of interventions to solve constraints in smallholder dairy farms of the Western Highlands of Cameroon. The interventions consisted of improved breeding through introduction of artificial insemination, better feed supplementation, farmers training in milk processing and better veterinary services. Results show that there was a decrease in average monthly expenditures of 18% relative to the month before interventions started. Much of the expenditures were related to feed (38% of all costs). There was an overall increase in farm income. Close to 2/3 of the income were derived from milk products from home processed milk and culled animals. Only 7% income came from milk sold to the processing plant. The partial budget shows that before interventions, farmers lost $4.5/cow/month but gained $38/cow/month because of the interventions. The return was 2.32 and included opportunity income for milk home consumed and shared. When this opportunity income was ignored, the return stood at 1.93. The positive impact of interventions led to poverty alleviation and some farmers acquired more cows. A spill over effect is that more crop farmers are willing to be engaged at least partially in dairy farming. It will be good if many more farmers could benefit from these interventions.

Key words: Cameroon, interventions, partial budget, smallholder dairy

6.2. Introduction

In Cameroon, the livestock sector represents 16% of the agricultural production in terms of Gross Domestic Production, providing 118 billion FCFA a year to the country. This represents 30% of the revenue of the rural population. The livestock sector is dominated by ruminants and the country has 5 million cattle with 4% being dairy (FAO, 2004). Between 1990 and 2004, the increase in human population growth was +2.2% per annum, while self-sufficiency in terms of milk production has decreased by –7.3% points within that period. Consequently the current ratio of imports / national consumption is 24% (Ndambi and Bayemi, 2006).

In order to improve local milk production, a first step involves understanding the local dairy production environment. A Participatory Rural Appraisal (PRA) was then devised to address the following questions: What are their constraints and limitations? What stakeholders and factors influence dairy production? What are the typical marketing channels? What are the perceptions of dairy farmers regarding dairying and what suggestions can be made to improve dairy production in the country? What are acceptable economic reference points that can be used to evaluate the outcomes of management interventions (Bayemi *et al*, 2005b)? A second step involved an Economic Opportunity Survey to evaluate the state of small-scale dairy farms and to determine the most important economic opportunities, with the eventual goal of addressing such opportunities in a holistic manner (Bayemi *et al*, 2007d).

It was found that the main constraints to dairy production in Cameroon include in order of importance: : poor marketing opportunities and long distances to market, limited grazing land and poor supplementation of cattle, limited health control, inadequate knowledge in processing, conservation and storage of milk, poor reproductive management and prolonged calving interval, lack of water in the dry season, poor housing, poor organization of group, limited number of dairy cows and poor record keeping. In market oriented farms, reproduction and feeding were the most important constraints. Main factors influencing dairy production are: milk collection, fresh milk price, consumer demand and management. Milk production per cow was shown to be the most important factor that influenced the economic viability of the system.

In order to address these constraints, interventions were set up to improve milk sales and increase milk production per cow with the hypothesis that these will improve the financial income.

6.3. Materials and methods

6.3.1. Choice of area

The North West Region of Cameroon is in the mid to high altitude zone, 5°20' - 7°00' N and 9°40'-11°10' E. Altitude varies between 300 - 3000 m, and annual rainfall is 1300 - 3000 mm, with a mean of 2000 mm. The dry season lasts from November to mid-March, and the rainy season from mid-March to October. Air temperature can exceed 30°C, while mean daily minimum and maximum temperatures vary between 15.5°C and 24.5°C, respectively. The human population is estimated at 1.82 million (Winrock International, 1992).

This site of the study was chosen because it was the most appropriate environment for dairy production in the country. This area is free of Tse Tse fly and it is close to the two major towns, Douala and Yaoundé with a good road network. Temperatures are the lowest in the country and therefore suitable for high yielding dairy breeds. In addition, milk production in this area is a government priority. A dairy technology laboratory was established in the area to improve milk processing. Furthermore, the Heifer Project International, an international Non-governmental Organization (NGO) has established its head quarters in the region to closely help farmers in dairy management. The Western Highland region is therefore very suitable for the improvement of dairy production and was thus chosen.

6.3.2. Selection of farmers

Dairy farmers who participated in the study were selected by means of the Economic Opportunity Survey (Nordlund *et al*, 2007) and on the basis of commitment to long-term collaboration in the research project. They were from the peri-urban area of Bamenda city.

6.3.3. Production and management systems

Twenty two farms selected were from the zero grazing system where grass was cut, chopped and provided to animals in feeding troughs. The majority of these cattle were Holsteins. Two farms were from the semi intensive system herding Holstein crosses *(Bos taurus x Bos indicus)*. Cows were offered concentrate diets during milking. The semi-intensive farms had sleeping paddocks or sheds constructed of wood with zinc or grass roofs. Cows were milked in the sheds with concrete floors. Many farmers use purebred Holstein bulls for natural mating.

Major dairy cattle diseases in the region are, in order of importance (Bayemi *et al.,* 2005b), ticks and tick born diseases (babesiosis, anaplasmosis, dermatophilosis, cowdriosis), mastitis in lactating cows, diarrhoea, foot and mouth disease, black quarter and ephemeral fever. Gastrointestinal parasites are also very prevalent. Non-governmental organizations or private veterinarians provide veterinary services. Vaccination is done yearly against black quarter, haemorrhagic septicaemia and contagious bovine pleuropneumonia. Only a few farmers spray dairy cattle against ticks, but hand picking of ticks is more common.

6.3.4. Interventions

Constraints identified by the PRA and EOS led to the setting up of interventions geared towards improving milk sales and milk production per cow. This was done by: 1) Encouraging farmers to be involved in the zero grazing system and keep the Holstein breed. Spreading this breed was done by introducing artificial insemination using chilled semen 2) Devising ways to help farmers increase forage consumption by pasture improvement, putting them in contact with hay producers and formulating a new feed concentrate 3) Advising farmers to supplement better yielding cows based on stage of lactation 4) Training farmers in milk processing to cheese and yoghurt in order to improve the shelf life of milk and therefore better sales 5) Linking farmers with better health care services. These interventions were applied in an integrated way. Any problem faced by a farmer could be solved whether it be in the area of marketing, health, management or reproduction.

6.3.5. Data collection

Twenty four farmers were given three different cards to record farm information. Cards were of different colours therefore helping the farmer to easily recognize them. Red cards were used to record daily farm expenses. These expenses included the following aspects namely, feed cost, veterinary medicine, hired labour, material for repairs, breeding / artificial insemination, pasture improvement, land renting, milking or processing material, and others. The green cards included monthly income: quantity of milk sold to processing plants and cost, milk sold in informal market and cost, home consumption of milk, milk fed to calves, milk used for home processing, manure sold, culled animals, bull leasing and forage material sold. The blue card included milk production per cow and could combine monthly production in the farm. Each farm was visited once per week by a team of technicians.

6.3.6. Analysis

Data were collected over a two-year period. The month immediately before the start of the program was used as the baseline. Not all farmers recorded data every month; all available monthly averages were included in the analysis. A partial budget method was used to calculate the benefit of the interventions.

6.4. Result and discussion

6.4.1. Expenditures

The interventions resulted in decreased expenditures (Table VI.1). Much of the reduction in costs was in the areas of repairs, hired labour, feed cost and ‘others’. Farmers could efficiently use the labour as the records now helped them to see what was spent in these lines. A feed was formulated so as to reduce its cost while retaining its efficacy. Other expenditures related to transport were also drastically reduced. Farmers were now able to make concentrate at home. Most farmers used cooperative owned bulls and did not previously incur a cost to breeding. On the other hand, the need for veterinary services was shown to farmers. This led to an increase in veterinary care costs of up to 65% relative to the situation before the interventions. An increase in veterinary care is related to an increase in the awareness of good general management for the cows. It was found that much of the expenditures were related to feed (38% of all costs). This shows that even in intensive small scale dairying, feed cost accounts for most of the expenditures. Consequently it is good to continue using local agro industrial by-products in feed formulations. These are: cotton seed cake, rice, corn and wheat bran, palm kernel cake, brewers grain and bone flour. Overall monthly expenditures per farm with or without interventions were higher than those reported by Tambi and Vabi (1994) and Pingpoh (1985) of $15 and $17 respectively (taking $1 US at 500 FCFA). This may be an indication of an increase in investment that may reflect the expansion of dairy in the area.

6.4.2. Income

Income data is shown in Table VI.2. There was an overall increase in income. In South Africa, interventions led to an increase in income of nearly 120% in the first year and 220% in subsequent years (Braker *et al*, 2002). Increased income from milk was mainly due to the fact that some farmers started selling milk to the processing plant. The research team organized farmers to use common transport to deliver milk to the processing plant. Much of the income is also derived from sold animals. In the Western Highlands of Cameroon, large numbers of animals are often a sign of prestige to farmers. They keep bulls and unproductive cows therefore wasting time and resources. Culling these animals led to a substantial improvement of income. Dairy farmers are also mingled with crop farmers. The latter did purchase manure from cattle as fertilizer for arable crops. Income from milk processing also improved, particularly because of training offered to farmers in cheese and yoghurt processing. There was a huge reduction of home consumed or shared milk. Due to the fact that farmers now processed more milk or delivered it to the processing plant, less was left for home consumption and sharing. Vabi and Tambi (1996) already found that improvements in the standard of hygiene and techniques of transforming fresh milk into other dairy products were acceptable strategies for intervention in the peri-urban milk producing areas of the North West Region of Cameroon. Finally farmers concerned in this study started to sell forage material, *Brachiaria spp* seeds and *Trypsacum laxum* cuttings. Before interventions, some of them did not even know that they could improve their pastures. They used naturally grown *Pennisetum purporeum.*

As regards total income, close to 2/3 were derived from milk products due to processing and culled animals. Only 7% income comes from milk sold to the processing plant. This is because of bad roads and poor management of the plant. This is similar to the Kenyan experience where 6% milk is sold to Kenya Cooperative Creameries (Stall *et al*, 2001). It is therefore necessary to expand milk processing training to other farmers not previously involved in interventions reported in this work.

Table VI.1. Expenditures due to interventions ($ per cow per month)

	Feed cost	Vet cost	Hired labour	Repairs	Breeding	Pasture	Land rent	Processing materials	Others	Total
Interventions expenditures Per cow per month ($)	15.81	5	7.83	5.97	0.21	3.24	0.14	0.88	2.03	41.10
Expenditures relative to total costs	38.47	12	19	14.53	0.5	7.87	0.34	2.15	4.93	100
Percentage reduction or increase in expenditures relative to month before interventions started	-21.4	65	-30	-57	100	-18	100	-1.75	-85	-18[a]

[a] total percentage relative to first month

Table VI.2. Income due to interventions ($ per cow per month)

	Milk sold to plant	Milk sold to informal costumers	Milk consumed or shared	Milk to calves	Income from milk processing	Manure sold	Sold animals	Bull leasing	Forage material	Total
Interventions income Per cow per month ($)	6.8	4.5	14	0.82	33	0.4	35	0.4	0.08	95
Percentage relative to total income	7	5	15	1	34	0.45	37	0.45	0.1	100
Percentage reduction or increase in income relative to month before interventions started	88	-104	-1082	-15	19	49.5	80	-17	100	11

6.4.3. Partial budget

Before interventions, farmers lost money. This led some of them not to buy feed for the cows. Those much interested in cash income neglected their farms and dairy cooperatives withdrew animals loaned to the negligent farmers. There is little incentive for improved management when farmers do not see a regular income or do not see any benefit in their business. Those who continue in this case expect their benefit from sales of offspring. Before interventions, farmers lost \$4.5/cow/month but gained \$38/cow/month because of the interventions. The return was 2.32 and included opportunity income for milk home consumed and shared. When this opportunity income (milk home consumed, shared or given to calves) was ignored, the return stood at 1.93. Interventions in addressing cattle diseases have proven to have a positive economic impact. The findings after controlling contagious Bovine pleuropneumonia in twelve sub-saharan African countries revealed that interventions were economically beneficial as all the benefit-cost ratios were positive in respective countries ranging from 1.61 in Ghana to 2.56 in Kenya (Tambi *et al*, 2006). The increasing rate of urbanization evident in Cameroon appears to depress the dietary role of cereals, roots and tubers in favour of the increasing importance of milk and dairy products (Tambi, 1998). The consumption patterns will probably continue in this trend therefore paving the way for much development of dairy production.

The cost of milk given to calves, home consumed or shared was estimated. This was reflected as an income because of the benefit derived by calves, family or neighbours, which led to a substantial profit and return (Table VI.3).

6.4.4. Impact of the interventions

A PRA carried out to evaluate the impact of interventions showed that farmers saw the positive effects of the project in their dairy farms. They were now able to know through expenditures and income records, the profitability of their farms. They were happy that breeding and health interventions were able to reduce the calf production interval. In such an area where malnutrition is rampant, families owning dairy cows saw a reduction in the frequency of human diseases. A survey revealed that 71% of people stated 'health and nutrition' as important reasons for drinking milk (Goldman *et al*, 1984). These aspects contributed to poverty alleviation. In Uganda and Kenya a scheme of introduction and improvement of small scale dairy production systems also alleviated the pressure of families struggling with poverty (International Agricultural Development, 1999). As in Kenya (Kidane, 1993), one dairy cow of a good breed can be enough to ensure a good income for smallholder farmers. The positive impact of interventions in Cameroon has enabled some farmers to acquire more cows. A spill over effect was that more crop farmers are now willing to be engaged at least partially in dairy farming. Farmers were keen to see the project continue. It will be good if many more farmers could also benefit from these interventions.

Table VI.3. Partial budgeting form (with milk shared, home consumed milk, and milk fed to calves opportunity cost)

INCREASED INCOME (per cow per month (liters))		**INCREASED COSTS (per cow per month (liters))**	
Additional Income generated from the program		Costs as a result of the program	
Milk sold (program)+opportunity costs	$95.00	Farm costs (program)	$41.00
MINUS		MINUS	
Milk sold (pre-program)	$85.40	Farm costs (pre-program)	$48.50
Difference in Income	$9.60	Difference in Costs	-$7.50
		Income minus Costs(profit)	$54.00
		Net profit	$17.10
		Income divided by Costs(return)	2.32
		Net return	0.56

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CHAPTER 7

7. Improving the dairy production sector in Cameroon

7.1. Abstract

A study was carried out to investigate to effect of an integrated method to improving dairy systems in Cameroon. This involved reviewing dairy research done in the country, carrying out a participatory rural appraisal and an economic opportunity survey in selected dairy farms, setting up on-farm interventions, investigating cow reproduction, evaluating milk quality and the impact of integrated interventions. Guidelines for improvement of the sector were set up. It was found that the integrated approach had a positive impact as farmers adopting interventions to solve constraints had nearly 200% economic returns in cash. In order to boost the Cameroonian dairy section, it is suggested that the government acts as a dragging force by organizing the market, ensuring the monitoring of epizootic diseases and providing artificial insemination services and organizing breeding societies. It is also suggested that the integrated method becomes a discipline in dairy science.

Key words: Cameroon, integrated method, interventions, small holder dairy, small scale dairy

7.2. Introduction

Milk production in Cameroon stands at 184 000 tons (MINEPIA, 2002). Yet the demand of milk products is far above production and 24% of national consumption is imported (Ndambi and Bayemi, 2006). Due to urbanization and population growth, milk production needs to double by the year 2020 if it is to meet the demand (Ndambi *et al*, 2006). Therefore, efforts have been gathered to increase production (Bayemi *et al*, 2005a; Bayemi *et al*, 2005b). Domestic production has for long been ensured by pastoralists keeping traditional zebu cattle (*Bos indicus*) in extensive systems where milk is a by-product of beef production. The introduction of improved European milk breeds (*Bos taurus*) such as Jerseys and Holstein led to the existence of semi intensive and intensive systems with agriculture being closely associated with dairying. However the efforts of Non-governmental organizations, Research and government institutions failed to significantly boost domestic production because farmers did not see the economic gain associated with potential biological improvements (Perera, 2007). A hypothesis was then devised whereby an integration of interventions at the level of farmers associating nutrition, health, reproduction and management would bring more economic benefits to small holder farmers and improve dairy production. This involved reviewing dairy research done in Cameroon, carrying out a participatory rural appraisal and an economic opportunity survey in selected dairy farms, setting up various interventions on farms, investigating post-partum resumption of ovarian activity, study the epidemiology of brucellosis and the impact of integrated interventions. This paper intends to evaluate the results of this work and set up guidelines for a successful sustainable improvement of dairy production in Cameroon.

7.3. Results of the integrated interventions

7.3.1. Research on milk production in Cameroon

Formal research on dairy cattle started in Cameroon in the early 1970's (Tchoumboue and Jousset 1982) on imported and local cattle. This research was extensive in the 1980's till date and mainly involved breeding, health and production systems (Mbanya *et al*, 1995, Kamga *et al*, 2001; Bayemi *et al*, 2005a; Bayemi *et al*, 2005b, Ndambi *et al*, 2006, Bayemi *et al*, 2007a, Bayemi *et al*, 2007b, Bayemi *et al*, 2007d ;Bayemi *et al*, 2008). Milk production in Cameroon has been characterized by the traditional system using local zebu cows (Gudali, White Fulani, Red Fulani). However, this production has been insufficient reaching only an average of 3 litres per cow per day. Per capita annual consumption was 10kg in 1984. Since then improvement in production has been possible thanks to importations of high yielding breeds such as Holstein Friesian, Jersey and others. This gave room to other semi intensive and intensive production systems in such a way that in 1998 per capita production was 12.8kg. Presently crossbred cows produce 12 litres per cow per day and pure bred Holstein go up to 25 litres per cow per day with hand milking. Little work has been done on nutrition using available local material. This is an area where research in needed, particularly in adapting research done in similar environments in other countries to Cameroonian conditions.

7.3.2. Participatory rural appraisal

A Participatory Rural Appraisal (PRA) was conducted in dairy farms of the North West Region of Cameroon. The aim of the PRA was to have a better understanding of the prevailing dairy systems, identify problems, and set priorities for research and development that can contribute to improved systems of production. It was found that five small scale dairy production systems are found in the region (Bayemi *et al*, 2005b): transhumance, improved extensive, semi intensive, zero grazing and peri-urban. Agriculture is well integrated to dairying. Main constraints include in order of importance: poor marketing opportunities and long distances to market, limited grazing land and poor supplementation strategies, poor reproductive management and poor calving interval, inadequate knowledge in processing, hygiene and milk preservation, and limited health control. In market oriented farms, reproduction and feeding were the most important constraints. Main factors influencing production are milk processing plant, consumer demand, fresh milk price and genotype/management. The marketing channel involves processing plants and open markets.

Recommendations were geared towards government and research institutions working more to help farmers to solve constraints. Processing plants were also advised to find ways of establishing more confidence with farmers in the measurement of their milk. Women were found to be more involved in milk production and benefiting more of the marketing. This is a good prospect for their welfare if production improves. The most urgent interventions to follow in market oriented farms seems to be tackling constraints of failure in reproduction and heavy work load in chopping grass. This is coupled with the extension of improved feeding and breeding methods.

7.3.3. Economic opportunity survey

The Economic opportunity survey (EOS) showed that medians (range) of three (0-24) and four (3-10) litres of milk were sold per farm per day, corresponding to 30% and 60% of milk produced; 24% and 13% of total cattle per herd were milking cows in the zero grazing and transhumance systems respectively (Bayemi *et al*, 2005; Bayemi and Webb, 2005; Bayemi *et al*, 2007d). More milk produced per cow per day represented the best economic opportunity in both systems while reduced age at first calving and longer lactation length were the next in both systems, respectively. Wastage of milk through spoilage from poor hygiene and lack of cooling was a major problem. Holstein cows, which were in the zero grazing system, had unexpectedly short lactations. Constraints found led to the setting up of interventions geared towards improving milk sales and milk production per cow.

Transhumance farmers are pastoralists and their herds cannot be easily monitored all year round because of seasonal movements of cattle. They were however encouraged to use AI because they are requesting to have some crossbred Holstein cows. This would be beneficial particularly to women and children because often the cow belongs to the men and the milk to the women. Transhumance farmers were also trained in reproductive management and milk processing. Partial budgeting was to be used to assess the financial benefits of these interventions and to provide evidence to show to other farmers to encourage them to follow suit.

7.3.4. Monitoring of reproduction

Poor reproduction was one of the constraints needing intensive investigation. Thus a human progesterone enzyme immuno assay kit more available in the country was tested for validation for use on cattle in Cameroon. Progesterone ELISA Kits (EH-511) were obtained from Clinpro International. It was found that this kit can be used for measuring progesterone levels in cattle. Cows with 1ng/ml for two consecutive samples or one sample at or above 3ng/ml are an indication of the presence of corpus luteum while cows below 1ng/ml will be in anoestrus. Therefore the kit was use for monitoring post-partum progesterone profiles in dairy herds (Bayemi *et al*, 2007c).

Pregnant dairy cows were selected for studies on post partum return to ovarian activity and milk production. The period of post partum first ovulation was 34.09±9.18 days in Holstein compared to 39.50±24.98 days for crosses and 55±25.93 days for local cows. The mean interval to first service was 58 days (Bayemi *et al*, 2007a). It was seen that in this area, cows producing more milk tend to take less time to resumption of ovarian activity. When cows were supplemented before calving for an investigation on the effect of feed supplementation before calving on milk production, ovarian activity and calf growth, there was little benefit of pre-partum supplementation on the parameters investigated. Consequently low income farmers are advised to concentrate their efforts of supplementation early in lactation.

7.4. Cattle health

Cattle were screened for *Brucella abortus* antibodies in 21 villages by ELISA. Results show a general seroprevalence of 8.4%. It was advised that a specific control programme be organized in the most infected locations and an effort should be made to determine the causes of the spread of the infection. Owing to the fact that animals screened are from the high milk yielding Holstein breed, measures should be taken to ensure the eradication of the disease within the population and sound control measures adopted to avoid a further spread of the disease to larger cattle populations in the region. It is recommended that infected animals should be slaughtered systematically. All farmers should be advised to boil milk before consumption. Vaccination against *Brucella abortus* should be instituted. In order to ensure a productive and healthy population of Holstein cows within the dairy production scheme, regular *Brucella* testing should be instituted.

7.5. Impact of interventions

Interventions designed in the study were set up to be carried out for two years. They primarily consisted of advice, education and training. This was done by: 1) Encouraging farmers to be involved in the zero grazing system and keep the Holstein breed. Spreading this breed was done by introducing artificial insemination using chilled semen 2) Looking ways to help farmers increase forage consumption by pasture improvement, putting them in contact with hay producers and formulating a new feed concentrate 3) Supplementation of better yielding cows by stage of lactation 4) Training farmers in milk processing to cheese and yoghurt in order to improve the shelf life of milk and therefore better sales 5) Linking farmers with better health care services. These interventions were applied in a holistic manner. Any problem faced by a farmer could be addressed, whether it be in the area of marketing, health, management or reproduction. They showed that there was a decrease in average monthly expenditures of 18% relative to the month before interventions started. Much of the expenditures were related to feed (38% of all costs). This shows that even in intensive small scale dairying, feed cost accounts for most of the expenditures. Consequently it is good to continue using local agro industrial by-products in feed formulations. There was an overall increase in income. Close to 2/3 income were derived from milk products due to home processed milk and culled animals. Only 7% income came from milk sold to the processing plant. The partial budget shows that before interventions, farmers lost -$4.5/cow/month and gained $38/cow/month because of the interventions. Returns were 1.93 and 2.32 without or with opportunity income for milk home consumed and shared. The positive impact of interventions led to poverty alleviation and some farmers acquired more cows. A spill over effect is that more crop farmers are willing to be engaged at least partially in dairy farming (Bayemi *et al*, 2008).

7.6. Guidelines for improving the dairy sector

7.6.1. Marketing

The most important constraint to dairy production raised by farmers was the lack of adequate market to milk. It seems sort of a paradox to increase the production of a farm commodity that lacks buyers. However, there is much demand for milk products in the country as the urban population is growing fast reaching already 50% of the total population (Bayemi *et al*, 2005a). Therefore a quarter of the milk consumed is imported. If milk were available it would be marketed. Ndambi and Bayemi (2007) showed that milk prices increase in Cameroon by +3.3% per year. This trend is to continue as predicted by Delgado *et al* (1999) with the livestock revolution. The vicious circle is that farmers are ready to increase investment, improve feeding and buy new breeding stock if they are sure that the milk will have a ready market. The informal market presently operating is insufficient in ensuring real market outlets to farmers. This is different in countries like Pakistan, India, Sudan and Uganda, where traditional, small-scale markets control over 80% of marketed milk (Stall *et al*, 2008). On the other hand business people would like to invest in the sector if they are sure that they will get enough milk to use their equipment at full capacity.

This is where the state needs to come in to subsidize initial investments necessary for marketing which may in future be sold to private investors. A good example comes from Operation Flood in India in the 1970's, where the dairy sector was heavily subsidized by surplus milk from the EEC. This led to a tremendous development and India is today the largest producer of milk in the world (MACDES, 2007). This subsidy can for instance come from the Heavily Poor Indebted Countries programme, whereby money that could have been used to pay the country's external debt is used for investing in the development of key sectors of the country. Such a scheme will surely boost milk marketing in Cameroon.

7.6.2. Feeding

The EOS showed that milk production per cow per day was the greatest opportunity. If farmers increased milk production per cow per day, they would get up to $1300 more per farm per year. Besides genetic make up of cow, feeding is a key factor which limits the milk production of dairy cows. In traditional systems, where communal grazing is practiced, the main feeding problem lies in the fact that less forage is available in the dry season which leads farmers to go on transhumance, a sort of periodic nomadism until grass becomes abundant again. But, because of demographic pressure, grazing land is gradually reducing and pastoralists must find alternative sustainable ways of feeding cattle (Ndambi *et al*, 2008). These farmers could then involve in pasture improvement with *Bracharia spp*, *Pennisetum purpureum* and *Trypsacum laxum.* Unfortunately most pastoralists are landless and are afraid of improving land that does not belong to them. In many places, there are permanent conflicts between croppers and graziers. The problem could be solved by having large commercial farms whose aim is to produce hay for these farmers. The second feeding problem faced by traditional stock keepers is that most cattle feeds commonly available in the tropics are nutritionally unbalanced (Sansoucy, 1995). They require adequate supplementation to ensure good productivity. These farmers should be encouraged to supplement cows with agro industrial by products. Giving just 0.5kg per animal per day will lead to great improvements in productivity especially in the dry season and this improvement will be sustained in the subsequent season (Njoya, 1997).

In zero grazing systems, grass is cut and chopped before being offered to cattle and they do not receive as much forage as they should. In this case as well, farmers could purchase hay or silage if available. The experience is that the few farmers commercially producing hay cannot honour all orders. Most farmers are very willing to improve feeding if milk market is available. As far as research is concerned little work has been done on nutrition using available local material. This is another area where research in needed, particularly in adapting results obtained in similar environments to Cameroonian conditions.

7.6.3. Milk processing and milk quality

Dairy plants make sweetened yoghurt, set yoghurt (natural), stirred fruit yoghurt, stirred plain yoghurt, and cheese. The following products are found at farm level: Pendidam (fermented milk), Kindirmu (Set yoghurt), heat treated milk, Lebol (butter), Nebam (butter oil) and sour milk (Kameni *et al*, 1999). Figure 7.1. shows that most milk consumed in Cameroon is either through the informal channel or on farm. However, dry imported milk is increasingly gaining ground.

Though milk products are not traditional in most Cameroonian habits, they become so because of rapid urbanization. There have been a number of small processing plants owned by small farmers' groups or milk cooperatives making primarily cheese and yoghurt, the two key products preferred by urban dwellers. This has been possible thanks to the training of farmers for processing by researchers of the Institute of Agricultural Research for Development (IRAD). This training also needs to be extended to milking and milk processing hygiene. It would be good if such training sessions were to be multiplied so that more farmers benefit from this knowledge. This will also help to increase the shelf life of milk for remote areas. The government should always ensure good milk quality by settings up standards and screening animals for Tuberculosis and brucellosis. Research therefore needs to be done in order to help in setting up acceptable standards for dairy products in the country

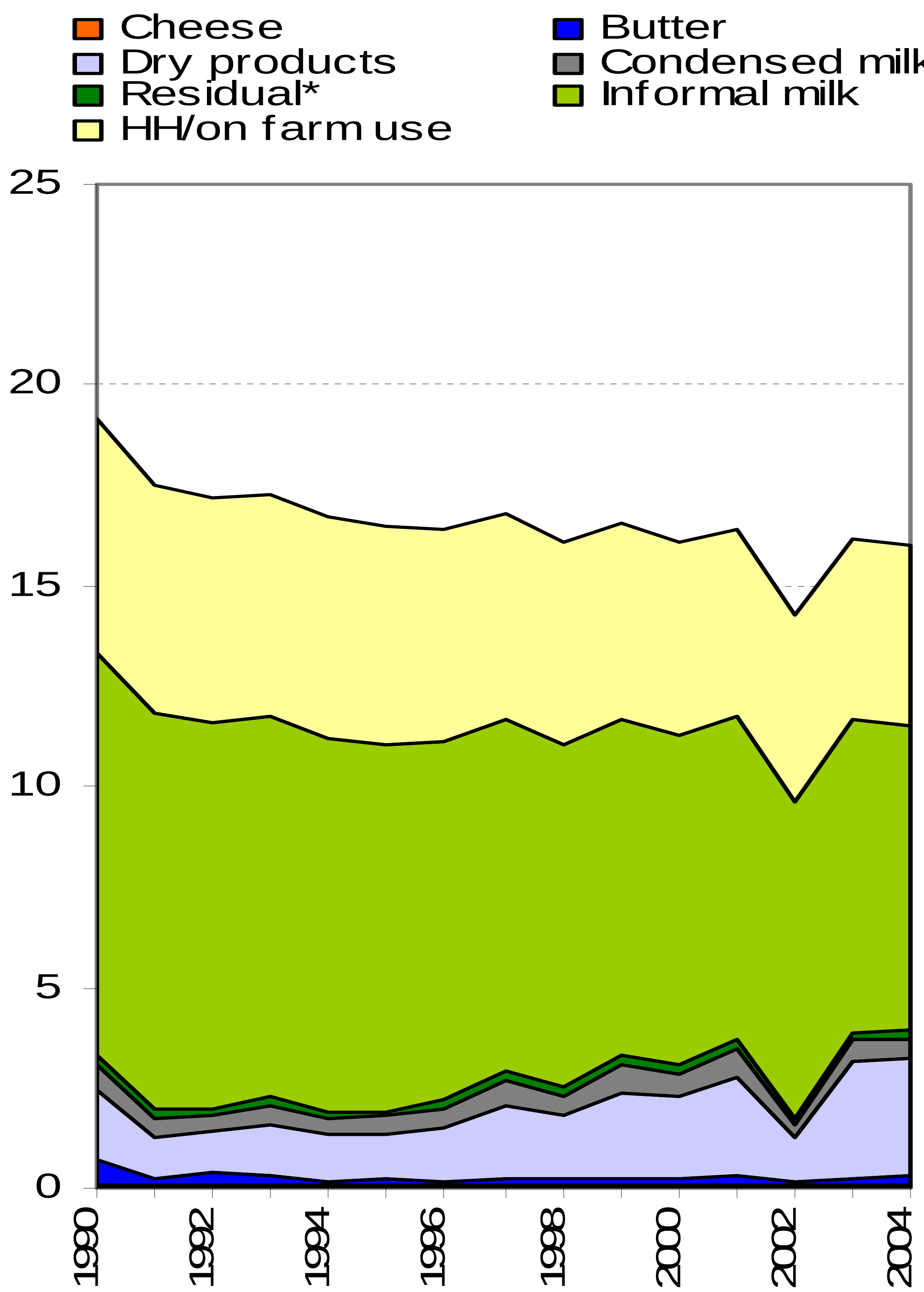

Figure 7.1. Consumption patterns of milk in Cameroon- Inkg ME (ECM)/ capita/ year

(Ndambi and Bayemi, 2006)

7.6.4. Breeding and reproduction

There is no official breeding policy in Cameroon unlike in Uganda which developed a comprehensive National Animal Breeding Policy in 1997 (Staal *et al*, 2008). Enough work has already been done on crossbreeding local with exotic dairy breeds (Bayemi *et al*, 2005a). These studies have recommended upon the use of F1 progeny. But because of the lack of a stabilized breed, there is a dependence on imported bulls or semen and artificial insemination. This leads to the lengthening of the calving interval in times of unavailability of imported semen and artificial insemination technicians. The dependence on imported semen has the advantage of farmers benefiting from genetic progress made in developed countries. However, as in the present situation, unplanned crossbreeding may lead to the disappearance of local breeds. Luckily, many traditional farmers are unwilling to crossbreed all their cows with imported semen because they are keen to keep the traditional breeds which have proven to be adapted to the challenging local environment. There is a need for research to tackle the preservation of local cattle genetic resources in the country, by characterizing, selecting and breeding local purebreds for meat production in order to lead to dual purpose F1.

Recently, artificial insemination has been introduced in the country using chilled semen with the financial support of the International Atomic Energy Agency, IAEA (Bayemi and Mbanya, 2007c). This is the first step to introducing an intensive use of frozen semen in the country as previous attempts were not sustainable because of the high cost of liquid nitrogen of nearly $30 per litre. There is a need that the government strongly supports such a scheme by making it possible for the AI centre to acquire nitrogen plants and means to distribute nitrogen throughout the country. Other aspects necessary for the successful breeding scheme include: organization of breeding societies for traditional and imported breeds; empowering of research institutions in the short term, to multiply valuable offsprings for milk production to be available to farmers, in the long term, to carry out research in stabilizing Cameroonian dairy breeds well adapted to local conditions; in subsidizing pregnancy diagnosis to be done by the AI centre. The extensive systems can use AI in selected cows while the zero grazing system is advised to rely on AI.

7.6.5. Health and management

In the 1970's, all cattle were vaccinated for free by the Cameroonian Government. The government later decided that farmers should show an interest by contributing to the vaccination costs. This led to the introduction of a subsidized vaccination charge of 390 FCFA (about 0.78 USD) per animal per year, for three major vaccines: black quarter, haemorrhagic septicaemia, and contagious bovine pleuropneumonia. For this reason, cattle owners expressed dissatisfaction and reluctance to attend vaccination campaigns (Ndambi *et al*, 2008). Since then there has been a liberalization of veterinary services in the country. Veterinary services are provided by non-governmental organizations or private veterinarians. Livestock government institutions need to continue to educate farmers on the need of prophylactic programmes.

One area needing much attention in dairy farms is record keeping (Bayemi *et al*, 2005b) where farmers need intensive training and follow up. Without a sound records keeping, it will difficult if not impossible to have a good monitoring of reproduction, progeny testing and registration of cattle. Owing to the fact that milk production per cow per day is the most economic limiting factors of dairy farms, it will be good for research to investigate three times per day milking and its consequences.

7.6.6. Milking cooperatives and general dairy policy

It has been demonstrated that proximity to a co-operative milk collection centre was significantly associated with an increased probability of a household successfully entering into dairy production (Baltenweck, 2000). In the Western Higlands, farmers have already been organized in successful dairy groups and cooperatives in which the government has very little control.

The Cameroonian government needs to practically be involved in improving the dairy sector. As already stated, it needs to boost dairy marketing by: 1) requesting that processing plants use a certain percentage of fresh milk instead of 100% imported milk powder. 2) creating and encouraging commercial dairy farms. In other countries like Ethiopia, India and Pakistan, the informal sector is the leader of dairy production but the Cameroonian case is different whereby most people did not have milk as a traditional diet and so the informal market is not developed in peri-urban major towns. 3) promoting and organizing AI services, breeding societies and registration of cattle 4) disease screening such as TB and brucellosis and carrying out a policy of eradication and control of these diseases (Figure 7.2).

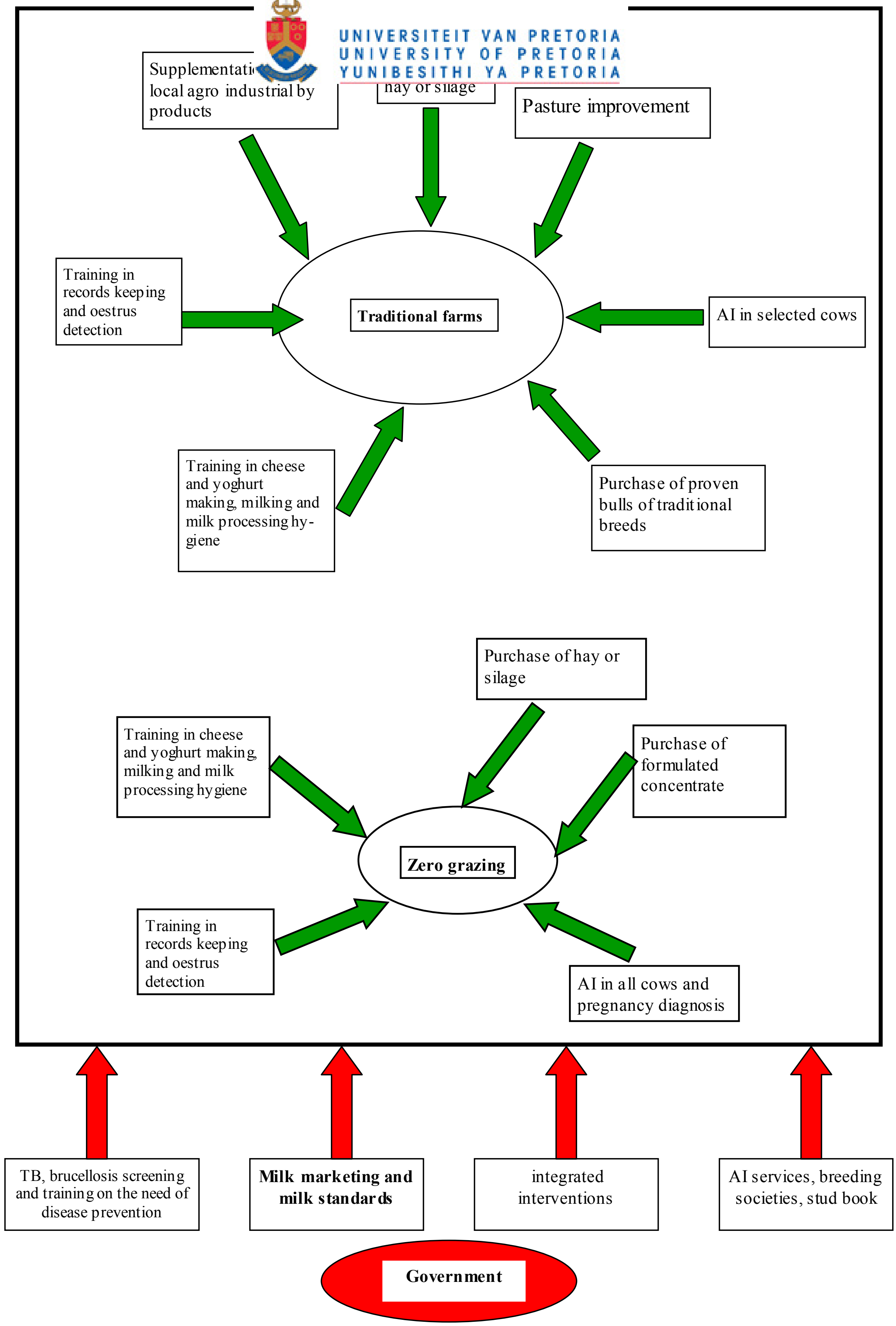

Figure 7.2. Actions needed to boost the dairy sector in Cameroon

7.7. Evaluation of the integrated approach in improving dairy systems

As already stated, in small scale dairy systems the uptake and use of research results by wider communities of farmers, organization and livestock extension services has often been less than expected. This in turn resulted in interventions for supplementary feeding, or for improving reproductive performance that did not demonstrate an economic benefit to the farmers. One of the reasons is that they focused on only one constraint or one discipline at a time, and other concurrent production problems were limiting the economic benefits. Therefore this study was designed to evaluate the impact of interventions carried out holistically. The PRA and EOS clearly demonstrated that many constraints concomitantly limit dairy production. It has been shown that an integrated method in solving these constraints will bring much improvement and clear economic benefits to small holder farmers.

For instance a farmer complained of the drop of 50% in the production of the whole herd. She suspected the effect of the dry season. The investigation of the 'integrated team' discovered that the feed mixture used did not contain enough protein and milking and milk processing hygiene were appalling. The solution to its problem was the formulation of a balanced died and training in milk processing hygiene, after which the herd production came back to normal.

Whitaker (2003) says that it is natural for someone trained in a particular discipline to fall in to the view that a problem and its solution lie within that discipline. That often clouds other aspects and approaches which may be more important. He reports a complaint from a farmer that an early lactation group were averaging 35 litres per day. Late calved, in the same mob and so having the same chance at the same food, had all normal energy measures and were producing 50 litres per day. The latter finding showed that the ration contained perfectly adequate energy for much more milk than the earlier were producing. So the cause of their energy stress was that they were not eating enough and not the energy density or content of the diet. Appetite in the new calved is always delicate by comparison to later on. Could anything be done here to help? Pre-calving nutrition and/or a change in components at calving were not constraints. What about access to food? These cows were milked three times a day. They spent two hours each milking in the collecting yard, being milked and waiting to be allowed onto bedded areas (for mastitis control), making six hours in total. Cows need to lie down – chewing the cud and sleeping – for at least 10 hours a day. That left only eight hours for eating. More food was not being put out until troughs were empty and so for some of that potential eating time there was often no food available. Ensuring that there were always enough food so that some was left – removed and fed to young stock – each time fresh food was put out and cutting the time spent around milking by half an hour solved the poor oestrus picture within weeks. The second example concerns a farm with 145 cows housed in cubicles in the winter months had a rate of 20% with severe lameness of sole ulcers. High protein feeding and rumen acidosis had both been blamed, investigated and changed in previous years – without effect. The milking cow area had 110 cubicles. 20% of cows dry at any one time in another house meant that 116 cows on average lived in 110 cubicles. In fact several cows always 'lay out' in the passageways – all of them 1st lactation heifers. A lack of comfortable lying time is the prime cause of laminitis related conditions such as sole ulcers. In cubicle systems more than one per animal is essential because cows do things as groups and all like to lie down together, all feed together and all drink together. More cubicles and new mattresses on the concrete beds resulted in a 70% reduction in lameness, 1000 litres per cow more milk and 15 days off the herd calving interval in the following year.

These examples show the pressing need for integrated interventions and open minds in dairy farms. Even when multidisciplinary teams work together there is sometimes a lack of interrelationship between various disciplines. In fact we can argue that there is a need of a new discipline, new specialists in integrated interventions. Though calling a team of 7 specialists may be expensive or difficult to carry out at every moment, it is possible to insert in the curriculum of veterinarians and animal scientists lectures on integrated interventions. There can even be a specialization on integrated interventions in deepening the relationships between various areas of actions on a dairy farm (Figure 7.3).

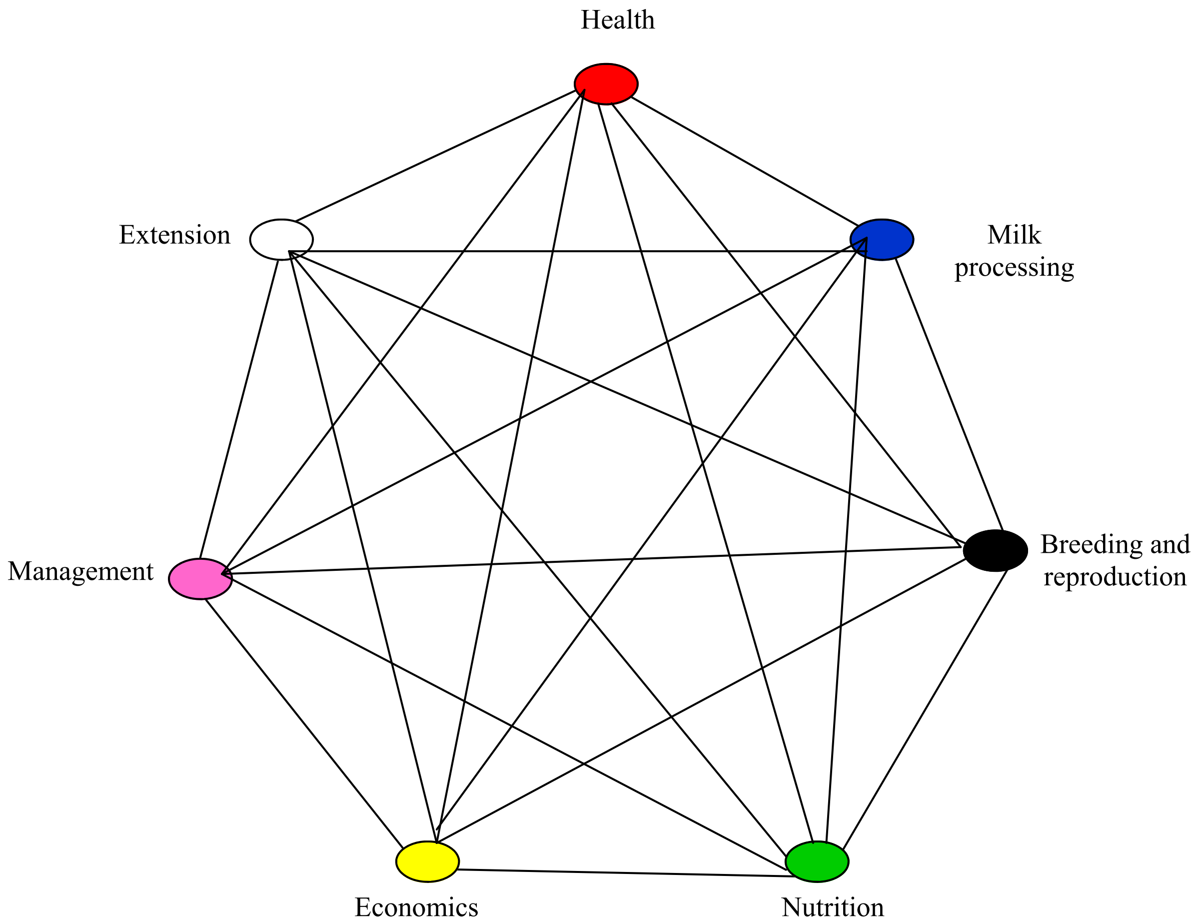

Figure 7.3. Diagrammatic representation of interactions between disciplines relating to integrated interventions

In Cameroon the application of integrated interventions in dairying requires the synergistic action from the government, researchers, non-governmental organizations and farmers. It requires expertise from many different fields and calls for the need to create integrated action teems in each administrative subdivision. Each team will be multidisciplinary constituted of an extension agent, an animal nutritionist, a veterinarian, a socio-economist, a dairy technologist and a reproduction scientist. It is quite likely that there be a lack of such specialists in each subdivision. In which case there can be a creation of intervention teams covering special areas of the country. It is not that these intervention teams will replace the private sector but they will guide local authorities in the extension of research results and in actions needed for regulation, advice and support the private sector.

7.8. Conclusion

This study has developped an integrated method in improving dairy production in Cameroon and has found that marketing and milk production per cow per day were the most limiting factors of dairy improvement. Interventions were carried out to solve these constraints and others. Farmers adopting interventions had returns of 193% and 232% with or without opportunity costs (milk home consumed, shared or given to calves) proving the positive impact of interventions using a holistic approach. These interventions need to be spread to more farms in the country. The integrated approach was proven to be effective in ensuring improvement of dairy systems in Cameroon. This method needs to be adopted for further dairy production improvement by the creation of multidisciplinary intervention teams and the training of integrated intervention specialists in the dairy sector.

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