# ESAP PROCEEDINGS

Fifth National Conference Of
Ethiopian Society of
Animal Production

15-17 May 1997
Addis Ababa, Ethiopia

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- International Livestock Research Institute (ILRI)
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- Ministry of Agriculture
- Ethiopian Science and Technology Commission

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## Preface

The Ethiopian Society of Animal production (ESAP) is a professional association which has been legally established on 17 August 1990 with the main objective being to promote animal production through sustained scientific research and development initiatives; in order to foster interest in the scientific development of animal production; maintained professional quality and academic standards and to provide national and international fora for the periodical exchange and dissemination of research findings and development efforts.

One of the various ways by which ESAP tries to meet its objectives is by organizing annual conference in which national and international research findings and developments in animal production are presented discussed amongst animal scientist and development practitioners; and subsequently, publishing the conference proceedings.

Five conferences have so far been convened by ESAP. In general, these conference provide to be successful in bringing a large number of professionals in the field of animal sciences and associated disciplines together, discuss on research and development efforts and at alleviating technical constraints of animal production and addressed policy issues. The proceedings of the first four annual conference have been published in large amount and distributed to various research, academic and grass root level national institutes, and international organizations both within and outside the country; and most of these have sent as encouraging feedback.

We are pleased to release the proceeding of the fifth annual conference which was held in may 1997. During the conference, six papers were presented during the plenary session and a total of eight papers in Animal production and 10 papers in feeds and nutrition group sessions. The papers presented during the plenary sessions focused on matters related to livestock demography; factors to be considered in livestock breeding strategy formulation, status of peri-urban dairying, poultry and small ruminants; dairy marketing.

The success of the society during the past years were the unreserved hours of volunteer service rendered by the members of the society and dedication of the executive committee. It is through the work of the members that our objectives are achieved in a timely manner. We appreciate the enthusiastic people who attended the workshops and members contribute to the success of the society.

Our society should serve as a catalyst in the formulation of approaches on the national research and development work to bring an impact in the livestock sector. We must be involved in all aspects of animal production so that our views are known to those making important decisions.

Many government and non-government organizations have financially assisted in sponsoring the fifth workshop and publication of this proceeding. We acknowledge their contribution with gratitude. We would like to thank Dr. Barry Shapiro for his constant encouragement and ILRI for financial support in publishing, and printing this proceeding.

February, 1998

Zinash Sileshi (Dr.)
President, ESP

# OPENING SESSION

## Welcoming Address

**Asfaw Yimegnuhal**
Vice President, Ethiopian Society of Animal Production (ESAP)

**His excellency Ato Getachew Tekle Medhin, Vise Minister of Agriculture,**
**Distinguished guests,**
**Ladies and Gentlemen,**

It is indeed a pleasure for me and I feel honoured to welcome you all to our 5th annual conference on behalf of the executive committee of ESAP and on my behalf.

This conference is planned to last for three days of which the first two days will be spent for plenary and group papers presentation on various aspects of livestock production while the third day is meant for post-conference tour. We hope participants will enjoy their stay with us and make their utmost effort to ensure that these three days are utilised ingeniously for further promoting the causes of our society.

The greatest global challenge confronting us today is feeding our ever increasing human population. Evidence shows that between 1960 and 1990 the world's human population grew by 75% and 97% of this growth took place in the developing countries. Currently some 800 million are known to suffer from malnutrition and hunger. The root cause of this problem is not only low production and unequal distribution but also due to the fact that poor people lack the income to acquire adequate food both in quantity and quality.

Human population growth projection indicates that the world population will increase from 5.4 billion in 1990 to about 7.2 billion in 2010. Growth trend suggest that increase will mainly happen in the developing world specifically in urban areas. This will have a far reaching implication on patterns of food production, marketing and consumption.

As a major component part of agricultural activities in the developing countries livestock could play a critical role in improving the ever worsening situation between food supply and demand due to human population pressure. The contribution of livestock to the overall economic development in general and to Agriculture in particular in the developing countries is often underestimated. They produce much more than food but since many important non food contributions are difficult to evaluate in monetary terms, they are commonly excluded from statistical calculation.

Improved efficiency of animal agriculture is a critical factor to achieve sustainable agricultural development and food security, particularly in low income food deficit countries where mixed crop/livestock production enterprises are exercised. Improved efficiency however, presupposes promotion of an effective technology generation and transfer system that is dependent on the use of local and affordable resources.

Improved livestock productivity is very much a function of capability of research to develop appropriate feeds and feeding systems, identify and use adapted

animal genotype, reduce mortality, improve production system and employ the necessary research and development policy environment. If we evaluate our performance against these measuring yardsticks, we will find out that we will have still a long way to go.

One of the goals of our society is to provide a common forum, via organizing a conference of this kind, for a periodical exchange of views among researchers, development personnel and policy makers in order to assist in promoting the development process of the livestock sub-sector. We are still far away from utilizing this forum as an effective mechanism to bring about policy changes that have been identified to be crucial for the welfare of the sub-sector. We have not eye-witnessed any of the resolutions passed, at the end of every conference so far, implemented. However, the establishment of the National Agricultural Science Congress and the preparedness of MOA have opened up venue to look into some of the resolutions. We need to develop stronger mechanism for these resolution to get prompt attention of the concerned authorities on the one hand, and we also need to seek ways in which our professional society goes beyond its current limit of serving as a compendium of technologies to playing a much more strengthened catalytic role in the improvement of the productivity of smallholder farmers on the other hand.

This year we sent out invitation letters to 68 government organization, 24 non-government institutions, 9 sister professional societies, all regional states and all members whose present address we were able to identify. As I have already indicated, we will be using the three days of our deliberations to the presentation of group and plenary papers, displays, and post- conference tour. All in all 25 papers (15 on animal production and 10 on animal feeds and nutrition) will be presented.

As the president of ESAP tried to under line last year in his welcoming address, our society is under severe financial constraint. This situation is still persisting and the executive committee would like to bring this issue to the attention of the general assembly for its serious consideration.

Finally, on behalf of the executive committee and on my behalf, I would like to voice my appreciation and to thank the institute of Agricultural Research, The Ministry of Agriculture, Farm Africa, Ethiopian Science and Technology Commission, and all others without whose sustained support, the organization of this conference could have not been possible.

I thank you all!!

## Opening Address

**Getachew Tekelemedhin**
**Vice Minster, Ministry of Agriculture, the Federal Republic of Ethiopia**

***Conference Participants,***
***Invited Guests,***
***Ladies and Gentlemen,***

It is a great pleasure and honour for me to welcome you all at the opening of this fifth annual conference of the Ethiopian Society of Animal production (ESAP).

As is well known, Ethiopia has huge livestock population. This sub-sector contributes 40 percent to the agricultural GDP (excluding non-monetary values) and also makes remarkable contribution to the country's rural development as it diversifies and increases total farm production and income and provides year-round employment. Sales of livestock products generate income for purchasing crop inputs and for financing farm investments. Livestock often form the major capital source of farm households and enhance the economic viability and sustainability of a farming system.

In almost all ecological zones, livestock production is a subsystem within the farming system and it should be seen in a system perspectives. Because of their linkage with the overall farming system, livestock make valuable entry points for wider agricultural development programs. The recent analysis of animal agriculture in Africa revealed that as population pressure causes animal agriculture systems to become more intensified, integrated crop-livestock production system become more efficient than the specialized systems of crop and livestock production. Despite the complementarity of livestock production system, the anticipated benefits are not fully realized and the integration of crop-livestock production is not yet developed. It appears that livestock production is highly marginalized in the system.

It is evident that in our development agenda the primary target of agriculture is food self-sufficiency. Attainment of self sufficiency in livestock products like any other agricultural product is a function of the natural resource base, the production technology and the production policy. Although with respect to natural resource base the country is endowed with huge livestock population and favourable ecology for livestock production, due to lack of capacity for proper management and utilization of these potentials, the country is in a position to import substantial amount of dairy products.

The most important limitation to livestock production in Ethiopia are those associated with production technologies. The average productivity per animal unit is extremely low for all classes of livestock and this leads to low per capita consumption of livestock products. Livestock production in Ethiopia is constrained by a wide array of factors among which poor standard of feeding, diseases prevalence and low genetic potential are the major biological factors. The expected increase in the flow of technologies to the needs and production conditions of resource-poor farmers in Ethiopia has not occurred inspite of considerable investments in research and technology transfer. It is therefore high time that we thoroughly review our development path, research agenda and policy environment with respect to livestock

Among the biological factors constraining livestock production, feed shortage and low standard of feeding are now being realized to be the overriding ones. Global experience in tropical regions of the developing world indicated that remarkable improvements in livestock productivity can be achieved if these constraints are alleviated. The reported scenarios in favour of optimized use of available feed resources is improvement in efficiency of feed utilization by ten fold and improvement in livestock productivity by five fold. Under local condition we can therefore target to improve traditional livestock production by five fold as result of improved feeding.

The other hard reality signalling the importance of improved feeding is the yield gap between on-station and on-farm performance of crossbred cows. On-farm yield performances are only half of what has been realized on-station. With the same genetic potential such a yield difference is mainly attributed to shortage of feed and low standard of feeding. Thus, we can not expect any improvement in livestock productivity without improvement in livestock feeding.

Small scale farmers now refrain from use of crossbred cows at the outset because of their inability to feed them. May I remind you that livestock production is often said to favour the richer segments of the society- both producers and consumers rather than the most vulnerable ones. On the contrary, experience in African countries like Kenya suggest that livestock development can only be achieved through the involvement of small sale farmers. The challenge is therefore how best to involve small scale farmers in the process of technology generation and transfer. National research program should not be a simple aggregate of activities defined by individual scientists but should be activities based on national development objectives or to farmers needs.

It is absolutely clear that previous effort to develop agriculture especially the livestock sub-sector have not been adequate. We should not deserve satisfaction from sheer livestock numbers. Because owning resources is one thing, efficient and effective utilization of the resources is quite another thing. Hence, we should strive to improve the quality of our stock. Quality improvement in terms of productivity should take precedence over an increase in numbers alone.

Based on the potential and expected yield ceilings, livestock production deserves special attention in transforming Ethiopian agriculture. The Federal Democratic Republic of Ethiopia is, therefore, giving special attention to the development of the livestock sub-sector more than ever before. During the last two years initiative was taken to prepare a strategy document on ruminant livestock.

Based on the document a national livestock development program and livestock development package have been prepared which address the major livestock development constraints.

This conference, I believe, is an ideal forum for all concerned individuals in livestock development to closely examine the interactions of crop and livestock in which population pressure causes animal agriculture systems to become more intensified and as a result mixed crop-livestock systems become efficient than specialized systems of crop and livestock production.

It is, therefore, expected that members of the Ethiopian Society of Animal Production renew their efforts and work in various areas of research which should assist the government in designing and implementing development strategies and policies which enhance the development of livestock sub-sector.

Generally, identification of appropriate strategies and providing decision-makers with soundly formulated policy alternatives are of paramount importance. Regarding the some of the policy areas I would like to draw your attention to are:

- Designing ways and means in tackling the problems of overgrazing which exacerbate the feed problem and marginalizes livestock as well as controlling the livestock from roaming around freely.
- devising ways and methods on how farmers should effectively use manure which is the principal soil amendment.

I hereby urge conference participants and all concerned individuals involved in livestock development to channel their effort to providing an integrated, coherent assessment of the role of livestock in agriculture and the economic development of the country and recommend policies that will enable the livestock sub-sector to contribute to the enhancement of food production, economic development and human welfare on an equitable, sustainable, and environmentally sound basis.

Finally, appreciating the organizers and wishing you all success in your deliberations, I now declare this conference open.

I thank you !!

## Keynote Address
## Looking ahead for Sustainable Livestock Development

**Beyene Kebede (PhD)**
**Head, Agriculture and Environment protection department, ESTC**

Ethiopia is a country whose agricultural sector is the biggest contributor to its GDP and major contributor to its export earnings. Currently the contribution of this sector to the GDP and export earnings is 48% and 90 %, respectively. The diversity of the ecology of the country has rendered it possible to support livestock production of all kinds and animal agriculture forms an integral part of the farming systems in almost all ecological zones of the country. The contribution of livestock and livestock products to agriculture in the country is 40% and this figure could even be higher if the non-monetary contributions are taken into account.

In the pastoral areas livestock is the sole source of livelihood and accounts for more than 60% of the household income. In the highlands, livestock is a source of meat, milk and cash for small holder farmers. Recent analysis by FAO suggest that contribution of livestock to total food production in developing countries increases at a higher rate and increases in livestock products appear to be more spectacular than those achieved for cereals from the green revolution. By the year 2010 animal products are expected to contribute proportionally much more to food supply than they do at present, since income determines the protein intake of people particularly in urban areas. Livestock production constitutes a very important component of the agricultural economy of the country, a contribution that goes beyond direct food production to include multipurpose uses such as skins, fiber, fertilizer and fuel. Further more, livestock are closely linked to the social and cultural lives of several million resource-poor farmers for whom animal ownership ensures varying degrees of sustainable farming and economic stability.

There has been no livestock census in the country since 1978, but it is currently estimated that there are about 33.8 million cattle, 25.4 million sheep, 18.5 million goats, 3.9 million equine, 1.0 million camel, 57.0 million poultry and 1.3 million beehives. Despite these huge resources, Ethiopia's livestock productivity is lower than the African average. Total herd offtake is estimated at 7% annually for cattle and 33 and 37% for sheep and goats, respectively. Live weight gains are low at about 20 kg annually and mortality is high at about 20%. Cows don't reach maturity until 4 years of age, calves every second year and produce only 1.5-2.1 liter of milk per day over a 150-180 days of lactation period. The major biological constraints contributing to low productivity include low genetic potential of the animals, poor nutrition, and disease prevalence. Many of these constraints have been clearly defined for a long time now, though no major break-through has been achieved for any livestock commodity or species productivity. It is therefore a high time that we critically review past achievements and define future directions of livestock industry with respect to development and research.

A hard reality with respect to livestock development in various developing countries, where Ethiopia is no exception, is the fact that many formal livestock projects have failed to meet their objectives with the result that donors are becoming more reluctant to support such developments. Many of the problems are the result of the inability to identify appropriate technologies and define strategies for livestock development that are applicable to individual agro-ecosystems. Often technology is transferred from developed countries unmodified rather than generating appropriate technologies locally. Imported technologies have almost always failed to overcome the constraints imposed on local farming systems or to meet the socio-

strategies are oriented towards better use of local resources, contribute more effectively to food security, improve the living standards of poor farmers and ensure sustainable animal agriculture development. The essential elements in this process are therefore to come up with a sound national livestock development program and the support of this development program with research.

From livestock development perspective, a careful planning is required because of the various controversies and the inherent complexity of livestock production. At a planning stage difficulties are not only related to the complexity of livestock production systems but also to poor knowledge of how these systems function; a problem of quantification and comprehension. An understanding of the production factors (livestock, capital, feed, land and labor) and the production processes and consumption is a prerequisite for livestock development.

Approach to livestock sector planning should be interdisciplinary since it combines the biological, social and economic sciences. It should also be dynamic in that it uses scenarios to anticipate future development. It should also be systems oriented. Analysis of the current performance of the sub-sector, potentials and constraints is an essential element in the diagnosis phase. This needs to be followed by a creative phase in which programs and policy options are formulated and designed to address identified constraints and potentials. Finally comparative assessment of the likely impact and implications of the prescribed programs and policy options need to be included in the planning for the success of the subsector.

From research point of view, livestock production was not supported by a clear and coherent national policy and strategy. A challenge at the moment is therefore how best to develop a sound national strategy document or a master plan for animal science research in line with the countries development objectives and strategies.

In Ethiopia the difficulties associated with increasing sustainable animal production are exacerbated by limited public-sector investment and weak, ineffective support services. Programs and projects are often poorly designed and inadequately targeted, leading to the inefficient and fragmented allocation of scarce development resources. Policies related to the livestock sector are often incoherent with ill defined goals and with little or no assessment of their likely impact. We should therefore strive for consistent and integrated strategies that focus the limited resources on identified and attainable goals. The success of this approach heavily depends on the strength of the linkage between research and development activities.

Recently few attempts have been made to strengthen the livestock subsector. The notable effort in this direction is the preparation of ruminant livestock strategy document and the preparation of livestock development programs based on the strategy. Though on a limited scale, another remarkable attempt is, the initiative to include livestock extension package in the agricultural development endeavors. Most of these activities have been given due attention by both at a regional and federal level Governments. It is therefore high time that you professionals adequately review past achievements, define future directions and goal in order to attain sustainable livestock development.

I thank you!

# PLENARY SESSION

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# Factors to be Considered in the Formulation of Livestock Breeding Policy

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## Abstract

Ethiopia has the largest livestock population in Africa, but the productivity of animals is poor. Annual livestock product growth is below the demand that is needed to feed the growing population. Carefully formulated policy that covers the whole livestock sub-sector or that deals with a single issue like livestock breeding will have a profound effect on development. There are a number of breeding options that could be employed. From experience of other countries with good example of livestock development, a combination of different breeding techniques based on economic and resource realities are recommended. Since livestock breeding is a long term investment, policy based on clearly defined objectives is highly needed. Some steps that could be taken during the formulation of breeding policy are suggested.

## 1. Introduction

Ethiopia has an estimated 29.5 million cattle, 21.7 million sheep, 16.7 million goats, 8.6 million equine, 1 million camels and 54 million chickens (ILCA, 1993). Livestock production is an important component of the national economy. Livestock share is estimated at 40% of the annual agricultural output and 15% of the gross domestic product (Abassa, 1995). Livestock play a significant role in the farm economy. They support rural and urban population with milk, meat, employment, investment opportunities, and draft power for crop production.

However, the performance of livestock as food producer in Ethiopia is poor. Meat and milk production annual growth is 1.8 and 2.8 percent, respectively (ILCA, 1993), which is below the recommended average rate of 4 percent that is needed to feed the growing population (Winrock International, 1992). The poor domestic production leads to heavy imports of animal products whose price is beyond the reach of the vulnerable groups.

Ethiopia has the lowest livestock productivity among East African countries. This is illustrated by taking production potential, cattle population, milk production, and annual growth in milk import and consumption (Table 1).

Livestock breeding has been in practice since the first domestication of farm animals in order to change one or more traits of animals that the owner thinks desirable under his environment. In addition, there is a natural selection which is simultaneously operating to provide reproductive ability and continuity of the genes of the fittest. The balance of the two has resulted in the present livestock breeds. The indigenous livestock breeds of Ethiopia are mainly the results of natural selection.

However, with the introduction of modern agriculture some effort has been made to introduce modern breeding practices targeted to improve productivity of different livestock species. In these programs of projected improvement small numbers of stock and resources have resulted in low contribution to the national scene.

Table 1. Potential agricultural land, cattle population, milk production, Annual milk import growth for Ethiopia and selected neighboring countries.

| Country | Highlands[1] (1000 Sqkm) | Cattle population (000 hd) | Milk production (MT) | Milk production (Kg/An) | Annual milk import growth %[2] | Per caput consumption of milk (kg/yr) |
|---|---|---|---|---|---|---|
| Ethiopia | 415.0 | 29500 | 800 | 213 | 23.7 | 25.6 |
| Uganda | 12.8 | 3905 | 372 | 350 | 8.5 | 19.7 |
| Kenya | 80.2 | 9500 | 1001 | 450 | NA | 51.3 |
| Sudan | 71.0 | 22400 | 1760 | 499 | 10.9 | 133.9 |

Sources: Compiled from Jahnke, 1982; Shapouri and Rosen, 1992; and ILCA, 1993.
[1] Suitable for Dairy Production
[2] Includes food aid and commercial imports. NA=not applicable

In most developing countries, there is a growing desire to replace or modify the genotype of economically important livestock species, but only few countries have effective policies on genetic improvement. Most of the countries have less than desirable success with imported purebred, disappointment with second and later generations of crossbreds, or no practical recording scheme to use in judging the merit of local or crosses. In this regard Ethiopia is no exception.

The aim of this paper is to provide points for consideration to the important issue of livestock breeding policy in the country. To elaborate some of the points, examples and experience from cattle breeding elsewhere have been used.

## 2. Livestock development policy issues and concepts

### 2.1 The importance of policy issues, objectives and instruments

Present-day ecosystems are a result of millions of years of "trial and error " in the co-evaluation of an enormous diversity of species. Systems are, by force or by choice, constantly changing and being adapted to environmental constraints. In the process, non sustainable species/breeds of animals and plants are being threatened with elimination mainly because they cannot favorably compete with the more efficient ones in terms of material output. Even where they are able to do so, because of their special adaptability features, there are no quantified comparative performance indicators that can boost their promotion.

The agricultural systems that have been built up over the past few decades have

contributed greatly to the alleviation of hunger and the raising of living standards. The development path emphasized technological innovation and maximizing productivity to meet short-term objectives. These have served their purposes up to a point where new realities are revealing their inherent contradictions. These realities require production system that also focus on people, resource and on long term objectives. only such system can meet the challenges of the future.

The characteristic low-external input farm systems reminiscent of the most parts of the country shall continue to rely on functional diversity through a combination of plant and animal species that have complementary characteristics essential for sustainable system stability and improved productivity are to be achieved. Decision-making of farm owners in these systems depends on the extent to which their specific objectives and ways of achieving them can be matched with existing technical opportunities and limitations.

Livestock development should, as a principle, be based on the matching of systems with the resource in a way that aims for economic optimization rather than biological maximization. In general, three conditions are essential for satisfactory progress in the livestock sub-sector:

a) There must be adequate resources, both physical (land, labor, good weather) and financial;
b) Suitable institutions (for research, extension, marketing, credit, etc.) must exist to develop and disseminate new and appropriate technologies to improve productivity; and,
c) Appropriate policies must be in place, both in the economy as a whole and in the livestock sub-sector.

The first step in seeking a new balance in the development of the livestock sector is careful evaluation of the viability of each breed and production system in terms of their economic, ecological and socio-political sustainablity. This can then be assessed against the alternatives available to producers. This concept has been realized after transferred systems and technologies became increasingly difficult to sustain in light of frequently excessively high production costs and limited market outlets for the smallholder rural producer. There is now a substantial body of evidence to show that policies have been major determinants of progress.

Policy is defined as a projected program consisting of desired objectives and the instruments to achieve them. Policy, therefore, has two basic elements: ***policy objectives and policy instruments*** (Colman and Young, 1989). Policy objectives are the ends of a policy, its overall purpose or long-term aim. They are what the policy is intended to achieve. Policy instruments, on the other hand, are the means of policy, the actions used to carry it out or the methods by which its objectives are achieved. Several alternative instruments often serve the same objective just like a single instrument may affect several policy objectives. The distinction, therefore, between objectives and instruments is very central in policy formulation and it enables one to assess the relative efficiency of each instrument.

Livestock policy or policies may mean either a complete package of decisions covering all aspects of the livestock sub-sector or a particular set of decisions dealing with a single aspect. Setting breeding policy for single species, like cattle, is a good example of the later.

## 2.2 National objectives are often based on five broad principles

independence, economic efficiency, resource conservation, stability and equitable distribution.

The ***independence*** objective is concerned with obtaining and preserving a satisfactory degree of political and economic autonomy. Meeting the independence objective requires a high degree of self-reliance.

The ***economic efficiency*** objective is concerned with increasing the level of real national income and its growth rate over time. Efficiency implies that a country uses technology to minimize costs per unit of output, and seek a combination of outputs consistent with its comparative advantage in the international market.

The ***resource conservation*** objective is concerned with preserving the natural resource base so as to ensure long term efficiency and independence. This objective is of particular concern because of the serious environmental problems, such as overgrazing, often laid at the door of livestock and the current thrust to conserve indigenous genetic resources.

The ***stability*** objective is concerned with avoiding abrupt and large changes in incomes, in the price and availability of domestically produced basic commodities and inputs and in the consequent need for foreign exchange to buy essential imports instead. Since stability is rarely secured without cost, absolute stability of prices and quantities should not be the aim. Indeed absolute price stability when production is inherently unstable can worsen both supply problems and farmers' viability. Nor should food security be confused with self-sufficiency in the production of all types of food. Agricultural markets, in particular, are inherently unstable. As a result, agricultural policy should be directed towards achieving an adequate degree of stability.

The ***equity*** objective is concerned with the fair distribution of income and wealth within society. Important equity considerations in relation to agricultural and livestock include the distribution of income and assets between different types of farms within and between regions, and the allocation of land use rights between producers. The equity objective also concerns the relative well-being of producers and consumers, the distribution of purchasing power between different groups of consumers, and the availability of employment opportunities. The market process alone will not normally lead to greater equity. Indeed, it may actually increase inequity, especially when the status quo is already inequitable or when economic power is becoming increasingly concentrated.

The simple principle for prioritization is concentration on those issues that are inherently most important and where changes in policy are likely to have the most effect. Essentially, this requires a thorough understanding of the livestock sector and in particular being clear about its current functions and the anticipated future role. It is necessary to know the present functions of the livestock sector in order to gauge how well it is performing in relation to policy objectives and to ensure that new policies designed to achieve new objectives do not, unintentionally or to an unexpected degree, disrupt the performance of existing socially desirable functions. In Ethiopia livestock have multiple functions with complex relationships. The relative importance of each function varies with regional grouping, production systems and agro-ecological zone. The most appropriate classification of the function of livestock sub-sector in

Ethiopia is on the basis of the use of outputs; for subsistence consumption, cash generation, savings and investments, social functions etc.

## 3. Genetic improvement: The options and strategies

### 3.1 Constraints to genetic improvement

#### 3.1.1 Physical and social factors

Ethiopia is located in the tropics. Climatic stress in the form of high ambient temperature, high humidity, and erratic or inadequate rainfall all detrimentally affect the productivity of livestock. Low fodder yield potential, high prices of concentrates, and the presence of wide variety of serious diseases were shown to add to the problem. Generally, high intrinsic production is physiologically antagonistic to heat tolerance, survival, and tolerance to parasites.

Poor education and management expertise of farmers, lack of knowledge at government and farm levels about the genetics of production, misunderstanding of production systems, lack of feedback to practical breeders, and shortage of qualified workers have been reported as major impediments for livestock improvement. Partial or complete lack of the infrastructure required for operating effective improvement programs has led to poor communication, inefficient recording systems, poor data collection and processing procedures, and unstandardized methods of evaluation.

#### 3.1.2. Breeding Objectives

Designing breed improvement schemes initially requires definition of the production systems and breeding objectives/genetic merit. Detailed economic assessments of costs and returns are rarely available in developing countries, and many geneticists or breeders have defined objectives in purely biological terms. In effect, testing and selection procedures and market policy are poorly coordinated. Many breeding strategies and breeding objectives more often fail to consider environmental constraints such as the potential feed resources and the outlook of livestock producers involved.

#### 3.1.3 Artificial breeding:

Artificial insemination and progeny testing are essential tools for genetic improvement of a large breeding population distributed over a number of herds. However, artificial insemination, oestrus control and other breeding activities appear to be too costly and sophisticated to suit the poor conditions in small farms and villages. The use of natural mating is, in many areas, more appropriate than artificial insemination. In areas where AI is working relatively better, its usage is indiscriminate and has no control over spread of genetic material and level of crossing. Some of the major causes for the failure of AI programs in many developing countries are:

1. Absence of proper AI facilities;
2. Inadequate roads and communication;
3. Lack of trained personnel;

4. Heat detection problems;
5. Presence of farm houses scattered over the village;
6. High cost of liquid nitrogen production;
7. Shortage of means of transport;
8. Lack of appropriate record and/or its utilization for genetic improvement.

### 3.1.4 Effective Population size:

A sufficiently large effective population size is important to maintain a high level of genetic variation and a low inbreeding rate, and to allow intense selection. Selective breeding programs in smallholder farms are handicapped by small population size and mixed herding of both sexes. As consequence of these it is difficult to identify superior males and females. Shortage of replacement stock, because of low fertility level related to inbreeding and other management problems is also a major impediment to undertake selections programs.

## 3.2. Breeding strategies and options

Milk and meat production in Ethiopia is based mainly on extensive traditional systems and its existence therefore relies on the use of genotypes that can produce effectively in these, often minimally improved, environments. Even when the direct and indirect effects of the physical environment have been ameliorated, significant increase in animal output can not be attained without change in the production potential of the animals (McDowell, 1996).

The production potential of the indigenous cattle breeds has often not been fully realized as these breeds have not been characterized fully for primary and ancillary traits. Improvement of the already existing genotypes or their replacement with "superior" genotypes depends on the knowledge of the attributes of these genotypes and the factors that affect production in those environments (Trial, 1984). Appropriate breeds may already be present, but are under-fed, under-managed and unassessed.

Genetic improvement is one method of achieving the goals of improving the productivity, profitability and maximal rate of economic or social gain. It is, therefore, absolutely necessary to find methods by which it can be optimally implemented. For example, a little improvement over a lot of cattle may generate a greater socio-economic impact and be more sustainable than a lot of improvement in a small elite herd. The breeding strategies available for genetic improvement can be categorized as follows: a) selection within available indigenous stock; b) substitution with temperate/tropical breeds with high production potential; c) crossbreeding/upgrading; and d) breed synthesis based on temperate x tropical breeds.

### 3.2.1 Selection within available indigenous stock

Indigenous cattle breeds in Ethiopia have been subjected to little artificial selection and designed breeding programs, and natural selection has been instrumental in fostering survival. These animals have evolved and adapted over many centuries in response to

selection pressure imposed by climate, altitude, available feed supply, endemic diseases and parasites, management techniques and market demands. They posses survival traits exhibited by small size, low milk production and slow maturing rate in addition to moderate levels of immunity, tolerance or resilience to prevalent disease organisms and parasites, excellent mothering ability, foraging ability, heat tolerance, ability to walk long distances, minimal water requirements, etc.

Heritability estimates of tropical cattle have been shown to be similar to those obtained in temperate countries, suggesting that tropical breeds posses sufficient genetic variability and could, therefore, be improved by selection. The Boran, Sahiwal, Red Sindhi, Tharparkar, Tuli, Tsawana, Nguni are some examples of tropical breeds that have been improved by selective breeding. For example, Mekonnen (1994) reported heritability estimates of 24, 29 and 34 %, respectively, for birth, weaning and yearling weights for Ethiopian Boran cattle. However, small herd size and lack of progeny testing possibilities will slow potential genetic progress that could be derived from sire selection within indigenous breeds. Nevertheless, improvement by selection may not be fast enough, but if properly designed, it will effect a more sustainable improvement in the long term. Moreover, crossbreeding and breed synthesis programs would greatly benefit from a selection program to generate the best indigenous dam lines. Some performance traits taken from selected indigenous cattle breeds are shown in Table 2.

### 3.2.2 Substitution with improved tropical breeds

There are now a number of promising high yielding tropical breeds which have been improved over a number of generations using selective breeding for production traits (eg. Sahiwal, Tharparkar, Tsawana, Brahman etc). Such breeds offer great potential for improved cattle production and could possibly be introduced and multiplied to replace or supplement the production functions of the unimproved indigenous breeds.

### 3.2.3 Substitution with improved temperate breeds

Introduction of exotic breeds is often considered to be the fastest but also the most expensive and risky way of genetic improvement in tropical countries. There are examples of Friesians' producing very high amount of milk in the hot climates of Israel, but this is supported by heavy investment in infrastructure, to the level that are un-affordable in many developing countries.l conditions.

Milk production of temperate dairy breeds in the tropical environments may be higher than for the indigenous animals, but this yield is still far much less (estimated at 60-70%) than what they produce in their home environments. In addition they have high mortalities and lowered fertility irrespective of greater veterinary care accorded to them. Financial losses are often very heavy because the cost of milk production using imported cows is often greater than the gross income possible, given their high procurement and maintenance costs. For instance, Holstein-Friesian cows under Ethiopian condition produce less than 3000 kg of milk per year, whereas the average for the same strain of cows in developed countries is over 6000 kg (;

Jasiorowski, Stolzman and Reklewski, 1987; Mureja, 1994; Mekonnen, 1994) (Table 3). It is very important, therefore, to recognize differences due to genotype x environment interaction which tend to increase with increasing animal size and yield potential of cows.

Table 2. Performance of indigenous breeds/types.

| | Indigenous breeds/types | | | |
|---|---|---|---|---|
| Traits | Boran | Horro | Arsi | Barca |
| Body weight (BW), kg | | | | |
| Birth | 24.5(1987)[+] | 18.3(198) | 21.5(64) | 22.1(134) |
| 6 mo | 115(1476) | 84(150) | NA | 99(120) |
| 12 mo | 156(662) | 112(140) | NA | 116(95) |
| Daily BW gain, g/d | | | | |
| Pre-weaning | 415(272) | 360(150) | NA | 420 |
| Post-weaning | 135(225) | 130(140) | NA | 100 |
| Milk yield, kg per lactation | 224(57) | 216(58) | 809(233) | 615(82) |
| Days in milk, d | 88(57) | 103(58) | 272(233) | 130(27) |
| Age at first calving, mo | 42.6(932) | 53(58) | 34(62) | 60(27) |
| Calving interval, mo | 443(4151) | 494(78) | 439(202) | 458(48) |

Sources:IAR, 1976; Kiwuwa *et al.*, 1983; Beyene, 1992; and Mekonnen, 1994.
[+] Values in parenthesis indicate number of records or animals
NA = Not available

In areas of high agricultural potential, grasslands and pastures will continue to be eliminated to allow for increased food crops production. It is in these areas also that a ready market for fluid milk exists and prices are most attractive to encourage dairy farming. Under such conditions, it is inevitable that the design of genetic improvement programs will have to synchronize the various germplasm resources with environmental resources most favored by economic and social conditions; the nutritional requirements for maintenance and sustenance of production against the available herbage and concentrates in both quantity, quality and cost. Breed substitution can be based on temperate breeds in areas where adequate infrastructure exist to support intensive commercial operation. Tendency of such practice of breeding in Ethiopia exists in peri-urban and urban dairying and dairy farmers in urban areas prefer high-grade cows than 50% crosses (Staal and Shapiro, 1996).

### 3.2.4 Crossbreeding and upgrading

In tropical countries, crossbreeding aims at combining adaptability of the hardiness, disease resistance and heat tolerance of native cattle with the high milk potential and faster growth rate of temperate cattle. Heterosis arising out of crossing of two diverse populations is greater in more stressful than in favorable (improved management, feeding and disease control) environments (McDowell, 1996). This implies that in an improving environment where crossbreeds progressively become inferior to purebred, crossbreeding is an investment of resources into a temporary solution.

Optimum proportion of genes from temperate or tropical breeds may be different for different dairy production systems (McDowell, 1996). A low proportion of exotic genes may be required to suit the limited feed resource in the traditional production systems. Large-scale crossbreeding, especially using AI, also creates a problem of maintaining a constant level of crossbreds. There are no appropriate guidelines for producing generations beyond the first cross. Consequently, indiscriminate crossbreeding programs are likely to lead to genetic dilution and loss of adaptability of the indigenous breeds and possibly the extinction of these valuable, but unrecognized breeds.

The reported performance of crossbreeds in tropical countries although excelling the pure native types, has been variable probably due to both environmental conditions and low dominance of genes for milk. The performance of different levels of crosses as deviation from native cows is shown in Table 3. Except in traits associated to milk production, the crosses are not superior to the natives.

The optimum breed composition from a *Bos indicus x Bos taurus* crosses could then be maintained by rotational crossbreeding or formation of a composite breed. However, the amount of heterosis retained with inter-se matings in a composite breed is not clear and reported performance in literature average 20-50 percent below the F1 parents (McDowell, 1989).

Maintaining and improving several exotic dairy cattle pure breeds or a crossbreeding program in a developing country could be costly. To benefit, this requires simultaneous changes in several other constraining factors like feeding, price of milk, marketing etc. which may require large amounts of money that are not readily available. More importantly, many exotic and crossbreds are often not fed enough to reach their potential because the additional milk produced may not be sold due to inadequate infrastructure or may fetch a price lower than that of concentrates. Importing frozen semen of high genetic merit from exotic breeds could be an inexpensive alternative. There may be problems in persuading farmers to maintain the rotational crossing if one breed (the exotic) is perceived to be much better than the other. For example, farmers might tend to upgrade to Holstein based on higher milk yield even though overall productivity, taking into account reproduction, meat production, draught capabilities and/or longevity may be lower in high grade than in the intermediate crosses. In such situations, crossbreeding is unlikely to work without effective support from extension services.

### 3.2.5 Breed Synthesis

In tropical countries, breed synthesis is increasingly being considered to be more advantageous than conventional crossbreeding because it offers a balanced exploitation of both additive and heterosis effects. It requires simpler structure than rotational crossbreeding. Breeders have made several attempts to form synthetic breeds well suited to specific environments based on the observation that in certain environments the most productive animals were intermediate mixtures of native and improved types maintained through inter-matings. A number of synthetic breeds have been developed in different parts of the world (Table 4). Based on lactation yield, all crosses fall within the upper range for $F_1$ crosses, but in annual milk yield they are not outstanding (McDowell, 1996). Synthetic breeds have often been recommended for use in grading up of native stock but this would require three or more generations to achieve yields of milk that can be obtained from Holstein sired first crosses. There will be reduction in milk yield in the first few generations in the synthetic group due to heterosis loss. Several generations of intensive selection would be needed to recoup the drop from inter-se matings. In most cases bulls of synthetic breeds are largely from government institutions; therefore, the effect of inbreeding can be a risk (McDowell, 1996). Therefore, creation of breed synthesis is complicated by the requirement that foundation stock be an improved local type and the necessity for a large number of milk-recorded herds fully involved in sire testing.

## 3. Breeding schemes for subsistence production systems

The conventional methods of improving the genetic potential of indigenous tropical breeds have been met with little success because of various technical, socio-economic and management factors. For example, indigenous cattle in the highlands of Ethiopia are often multipurpose, providing meat, milk, draught and sometimes dung for fuel and fertilizer. Breeding objectives are not so clearly defined as for specialized dairy or beef breeds. In most cases cattle are maintained under subsistence traditional production systems. They can be found in large nomadic herds or sedentary small holdings. Performance recording is difficult, if not impossible, to measure in such systems. Often the small herds are not recognized by more advanced official livestock breeding programs.

Sedentary production systems are less difficult to organize into breeding systems than nomadic operation. However, the sedentary system usually involves a very small herd size, and needs regular contact by extension and veterinary services, artificial insemination, exchange of breeding stock and germplasm into cooperative units and effective and sustainable support systems to ensure farmer confidence. Marginal to sub-marginal returns are a serious impediment to adoption of breeding systems designed to increase the genetic potential of the indigenous animals.

In many instances, the dominant livestock production system is still based on poorly described mixtures of native stock with low potential performance. These stocks have been raised by farmers for many years with no deliberate breeding program. These subsistence levels are likely to continue since livestock are usually considered secondary to crop production. Milk production will continue to rely on genotypes that can produce efficiently in these minimally improved environments. Considerable knowledge is required about the already existing genotypes to be able to appropriately decide on the strategies for their improvement or replacement with superior genotypes.

Table 3. Means for pure zebu(Z) and Friesian breeds and percentage deviations of fractional crosses of Friesian (F), Jersey (J) and Simmental (S) from zebu [1,2].

| Traits | Mean Zebu[1] | Mean Friesian | Percentage of Deviation | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1/2F | $F_2F$ | 3/4F | 1/2J | $F_2J$ | 3/4J | 1/2S | $F_2S$ | 3/4S |
| Birth wt, kg | 23 | NA | 0 | 13 | 21 | -17 | -8 | -17 | 0 | 13 | 25 |
| 6 mo wt, kg | 111 | NA | 3 | -9 | 1 | -8 | -14 | -14 | 2 | -12 | -6 |
| 12 mo wt, kg | 145 | NA | 6 | -7 | 1 | -3 | -12 | -13 | 5 | -11 | -7 |
| Daily body weight gain, Kg | | | | | | | | | | | |
| Pre-weaning | 396 | NA | 24 | 6 | 16 | 1 | 4 | 4 | 24 | -2 | 4 |
| Post-weaning | 133 | NA | 58 | 32 | 43 | 50 | 13 | 13 | 50 | 20 | 13 |
| Milk yield, kg | 618 | 3560 | 214 | 139 | 417 | 173 | 108 | 161 | 173 | 77 | 223 |
| Milk yield, kg/yr[3] | 509 | 2881 | 193 | 95 | 322 | 153 | 72 | 80 | 142 | 26 | 136 |
| Days in milk, d | 200 | 343 | 71 | 64 | 86 | 64 | 58 | 35 | 69 | 38 | 104 |
| Age at first calving, mo | 43 | 40 | -21 | 19 | -12 | -5 | 0 | -16 | 7 | 28 | 23 |
| Calving interval, d | 444 | 451 | 7 | 23 | 23 | 8 | 21 | 45 | 13 | 40 | 34 |

Sources: Kiwuwa etal, 1983; Beyene, 1992; Mekonnen, 1994; Mureja, 1994.

[1] Zebu = Pooled mean of Boran, Horro, Barca and Arsi breeds

[2] Breed group composition (breed of sire listed first): 1/2F = F x Z, $F_2F$ = FZ x FZ, 3/4F = F x ZF, 1/2J = J x Z, $F_2J$ = JZ x JZ, 3/4J = J x JZ, 1/2S = S x Z, $F_2S$ = SZ x SZ, 3/4S = S x SZ.

[3] Milk yield per year = 365 d/calving interval, days x lactation yield (kg); NA = Not available

Table 4 Performance of some synthetic breeds or strains originating in the warm climates zones.[1,2]

| Traits | Jamaica JH | Brazil PR | Australia AMZ | India | | Cuba | |
|---|---|---|---|---|---|---|---|
| | | | | KS | KF | Siboney | Mambi |
| Age at first calving, mo | 34.5 | 34.7 | 31.0 | 36.3 | 34.9 | 31.3 | 32.0 |
| Milk yield, kg | 2930 | 2780 | 1987 | 2519 | 3055 | 2897 | 2507 |
| Milk yield/yr, kg[3] | 2434 | 2452 | 1719 | 2215 | 2251 | 2610 | 2083 |
| Days in milk, d | 282 | 281 | 244 | 324 | 305 | 298 | 289 |
| Dry period, d | 158 | 132 | 130 | 94 | 66 | 129 | 100 |
| Calving interval, d | 439 | 414 | 422 | 415 | 437 | 405 | 439 |
| Body weight, kg | 394 | 422 | 386 | 368 | 427 | 430 | NA |

[1] Source: Adapted from McDowell, 1996.

[2] JH=Jamaica Hope (3/4 Jersey x Sahiwal);PR=Pitanquiras(5/8 Red Poll x 3/8 Zebu); AMZ=Australian Milking Zebu (3/4 Jersey x 1/4 Sahiwal or 1/4 Red Sindhi); KS=Karan Swiss (3/8 Brown Swiss x 5/8 Sahiwal or 5/8 Red Sindhi); KF=Karan Fries(3/4 European x 1/4 Tharparkar or 1/2 Holstein, 1/4 Brown Swiss, and 1/4 Tharparkar); Siboney (5/8 Holstein x 3/8 Zebu); and Mambi(3/4 Holstein x 1/4 Zebu).
[3] Milk yield per year = 365 d/calving interval, days x lactation yield (kg).
NA=Not available.

## 4. Conclusions

Formulation of livestock breeding policy like any other policies is the responsibility of legal government institution with the mandate to do it. In the past, some attempts have been made by the Ministry of Agriculture to produce cattle and sheep breeding policies, but none of these have been accepted as legal policy documents. But, now there is a political will and commitment to support the development of the livestock industry of the country. For example, with the approval of the government 'Ruminant Development Strategy Document' has been prepared and expected to be in operation very soon. Likewise, it is high time to revise or newly formulate sectorial policies (eg. Dairy/milk and Beef/meat production sector policy, etc.) in order to bring the desired level of development in the country. It is equally appropriate and urgent to have a national policy documents regarding breeding activities of important livestock species. As indicated in the breeding strategy and options section of this paper there are a number of technical alternatives that could be employed; however, each alternatives should be carefully weighed against the national policy objectives.

The concerned government institution should support and establish a national technical committee, which should be composed of professionals from different government and non-government institutions (universities, extension services, national planning and research institutes) and farmers' representatives engaged in the improvement and production of the targeted livestock species. Breeding policies should be prepared at least for each species or on a commodity base prioritized according to their relative contributions to the national economy. All or some of the following points are suggested to be considered by the technical committee during the policy formulation process.

(1) Search and collate relevant literature on previous breeding work and policies in Ethiopia and from other example African and tropical developing regions so as to determine the extent of knowledge available, determine information gaps, and priority areas for addressing national policy.

(2) Gather additional information from farmers and opinion leaders in a participatory process for generating national or regional breeding objectives and developing practical breeding programs.

(3) Consider the agro-ecological zoning of the country and its associated production systems as influenced by the socio-economic conditions and propose appropriate principles upon which selection, crossbreeding and introduction of new genotypes shall be based;

(4) Review the current role of modern breeding tools and technologies and level of application in the country (eg. artificial Insemination, embryo transfer etc.) and propose future functional roles;

(5) Consider and come out with practical recommendations on:
- Import and export of germplasm(s)
- Methodology for pricing of breeding materials
- Breeding and management systems for conservation and sustainable use of indigenous livestock resources
- Set priority research areas, and

(6) Propose institutional adjustments, needs and legal framework necessary for ensuring flexible but coherent and sustainable implementation of the policy guidelines.

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# Prospects for Peri-urban Dairy Development in Ethiopia

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## Abstract

The human population in Ethiopia, currently estimated at 60 million is growing by about 3.5% per annum. This figure will increase to about 139 million by the year 2020, making Ethiopia the third most populous country in Africa. The number of children under the age of 15 is projected to increase from 26.7 million in 1994 to 59.0 million in 2020, and the number of women at peak childbearing age (20 to 35) is estimated to reach about 15 million by 2020. urbanization is projected to grow to 39.2% by 2000. As a result, the demand for animal products, both in terms of quantity and quality, is estimated to increase substantially. Currently,the population of cattle, sheep and goats is 30, 23 and 17 million, respectively, with an estimated annual milk production of 800,000, 65,000 and 95,000 metric tones, totalling to 960,000 metric tones. Over the period from 1975 to 1987 average annual milk consumption was estimated at 1,101,000 metric tones and per caput consumption was 25.6 kg/year. In 1995/96, the annual per capita consumption dropped to 17 kg. Comparative figures for other sub-Saharan African countries and the developed countries are 26 kg and 200 kg, respectively. Average milk production is estimated at 213 kg/cow/lactation. Almost all indigenous cattle are in the hands of the smallholder subsistence farmers and average milk production per cow per lactation is estimated at 213 kg.Milk produced is used for either family consumption or sold at local markets often processed into butter and ayib (cottage cheese). On the other hand, market-oriented dairy production systems with improved genotypes are found mainly in urban and peri-urban areas. The annual national demand-supply variance for fluid milk alone, calculated on the basis of per capita consumption in sub-Saharan Africa, is estimated at 500 million kg. Based on this calculation, there will be a minimum annual demand for 1 billion 14 million kg of milk to satisfy the projected urban population of 39 million people by the year 2020. This is a great challenge and an opportunity for all people involved in the development of the dairy sector. Currently, the emerging and fast growing peri-urban dairy production systems operating at different levels of intensification is becoming one of the most important and dominant systems, particularly around big urban centres. The expansion, further development and sustainability of peri-urban dairy production systems has to be carefully examined as dairy production requires a relatively large initial investment and a long term commitment. In addition, the major technical and non-technical problems associated with these dairy production systems such as policy issues, land rights and ownership, availability and cost of dairy genotypes, feed resources and feeding systems, trained personnel, diseases,animal health and diseases, veterinary services, product quality, marketing, processing, absence of strong dairy association, etc. need to be addressed. In this paper, the status of dairy production in Ethiopia is assessed,and the potential for the development of peri-urban dairy production systems and the major constraints associated are presented and discussed.

## 1. Introduction

Ethiopia has a land area of 1,130,138 km$^2$ and the economy is mainly based on subsistence agriculture. Agricultural production is very low and there is an acute deficit in food supply. To this effect, food self-sufficiency has become a primary issue in the national agricultural development policy and programme. According to the FAO (1994), at least some 34 million people in Africa are suffering from severe malnutrition and hunger. The dramatic deterioration of nutritional status of humans has become a serious concern for both national and international institutions (National Planning, 1989,FAO, 1992), and strategies have been devised for a co-ordinated work to increase agricultural production in the rural areas.

The agricultural sector in Ethiopia accounts for 46% of the gross domestic product (GDP), and livestock contributes 30% to the agricultural GDP and 19% to the export earnings. Besides,about six million oxen provide the draught power required for the cultivation of grain crops. Although the contribution of the livestock sector to the national economy is quite high, animal productivity is extremely low. The fact that the country is importing milk replacers and milk products, while possessing the largest cattle population in Africa, is a very good indicator of the complexity of the problem. The low level of livestock productivity is also reflected in the very low per capita consumption of animal protein. The average per capita consumption of animal protein for the various regions of the world is presented in Table 1. In general, the per capita consumption of animal products in developing countries represents only 15 to 30% of that of the developed countries. For example, the average consumption of milk in developed countries is about 200 kg of milk per person per year and the figure for the USA in 1995 was about 300 kg as opposed to 27.5 kg for Africa.

In Ethiopia, the per capita consumption of milk is only about 20 kg, lower than for the average for sub-Saharan Africa. A study by the Ministry of Agriculture shows that the per capita milk consumption in Addis Ababa has dropped to about 25 kg in the 1980's to about 16 kg in 1996. Moreover, although data are not available, it is estimated that the largest proportion of milk is consumed by very small percent of high income groups in many urban centers. Almost all the fluid milk supply to major urban centers comes from urban and peri-urban dairy producers. The large demand-supply variance in milk, with a possible increase in the purchasing power of people may show the potential and opportunity for development of peri-urban dairy production systems.

## 2. Livestock resource and milk production

The total population of animals used for milk production (mainly cattle, goats and camels) in Ethiopia is enormous. About 42% of the cattle population are milk cows managed by the private sector. A total of about 960,000 metric tones of milk is produced annually from cattle, sheep and goats (Table 2), and quite substantial amount of the milk produced is converted or processed into better and ayib (Table 3). This reduces the total amount of fluid milk available for consumption. Moreover, average milk production per head per day is very low by any standard (Table 4). Total milk production is further affected by relatively short lactation length (Table 4) and extended post-partum anoestrus period resulting in lower reproductive efficiency

(Mukasa-Mugerwa, 1989). This is basically due to the fact that these animals have been selected primarily for survival traits and possess well established adaptive traits to the environment in they are expected to survive and produce.

Table 1. Per capita consumption of milk, meat and fish in 1990 (kg/year)

| Region | Milk | Meat | Fish | Total |
|---|---|---|---|---|
| World | 75.0 | 32.9 | 13.0 | 120.9 |
| Developed | 200.0 | 81.6 | 26.8 | 308.4 |
| Developing | 36.6 | 17.7 | 8.8 | 63.1 |
| Africa | 27.5 | 11.4 | 8.0 | 46.9 |
| Latin America | 93.9 | 41.1 | 8.6 | 143.6 |
| Near East | 60.7 | 19.6 | 4.4 | 84.7 |
| Far East | 27.0 | 15.1 | 9.4 | 51.5 |

Source: FOA, 1992

Livestock production systems in Ethiopia are mainly smallholder subsistence farming, with animals having multi-purpose use, and as such no specialized and systematic breeding is practiced. Given their low genetic potential for production traits, multi-purpose use and predominantly low input enterprises, direct comparison of the productivity of the indigenous animals with the specialized breeds of cattle in the developed countries is very difficult to make. Any attempt to evaluate and judge the indigenous cattle from such a perspective will be unfair and is unjustifiable.

Table 2. Population of cattle, sheep and goats in Ethiopia and their respective milk production.

| Species | Number (mill) | Volume ('000 MT) | YieldYield per Kg/antotal herd (kg/an) |
|---|---|---|---|
| Cattle | 30.000 | 800 | 21327 |
| Sheep | 23.200 | 65 | NANA |
| Goats | 17.300 | 95 | NANA |
| Camels | 1.050 | | |
| Total | | 960 | NANA |

Source: Central Statistical Authority, CSA, 1995. NA= Not Available

Table 3. National number and percentage distribution of cattle, aged two years and above by purpose for private holdings in 1994/95

| Purpose | Number ('000) | Percent |
|---|---|---|
| Milking cows | 8929 | 42.01 |
| Draught cattle | 8502 | 39.99 |
| Beef cattle | 337 | 1.59 |
| Other purposes | 3489 | 16.41 |
| Total | 21,257 | 100.00 |

Source: Central Statistical Authority, CSA, 1995.

Table 4. Average milk yield per cow per day, lactation length and percentage of milk converted to butter by region for private holdings in 1994/95

| Region | Yield/day (liter) | Lactation length (mo) | Percentage converted into butter/year |
|---|---|---|---|
| Tigray | 0.97 | 6.19 | 40.60 |
| Afar | 1.40 | 5.46 | 22.28 |
| Amhara | 1.05 | 6.57 | 40.13 |
| Oromia | 1.12 | 6.77 | 35.41 |
| Beneshangul | 1.04 | 6.00 | 25.15 |
| S.E.P.A.R. | 1.08 | 6.34 | 41.90 |
| Gambela | 1.03 | 6.16 | 13.97 |
| Harari | 1.10 | 6.17 | 2.05 |
| Addis Ababa | 1.50 | 6.74 | 54.08 |
| Dire Dawa | 1.43 | 6.91 | 3.52 |
| Average | 1.17 | 6.33 | 27.91 |

Source: Central Statistical Authority, CSA, 1995.

## 3. Human population and urbanization

The human population of Ethiopia which was 54.9 million in 1994 makes Ethiopia the third most populous country in Africa. This figure is estimated to double in a period of about 21 years. During the last ten years, the population grew by about 15 million and is expected to surpass 65 million by the year 2000. Ethiopia is also one of the countries with highest population growth rate in the World, estimated at 3.1% per annum. The number of children under the age of 15 is projected to increase from 26.7 million in 1994 to 59.0 million in 2020. The number of women at peak childbearing age (20 to 35) was 5.2 million in 1994 and will increase to 14.6 million by 2020. Urbanization is also expected to grow in the coming 20 years. In 1994, only 15% of the population was living in urban areas. The proportion of urbanization is expected to grow to 17.6% by 2000 and 29.2% by 2020 (Ethiopian Herald, 1996). The urban human population in major towns in the country is presented in Table 5.

## 4. Demand for dairy products

As indicated in the above sections, increase in total human population and accelerated rate of urbanization will characterized the Ethiopian society in the coming 25 year. Agricultural production has to cope up with these increase with a relatively decreasing numbers of farming communities on the ground; calling for more integrated and intensified agricultural production systems. Under smallholder farms limitations in farmland size and availability and market will determine the extent of integration and intensification of production. Increasing demand for more and diversified dairy products, particularly in urban centers, will be a major driving force and a challenge for the development of peri-urban dairy production systems.

Table 6 shows comparative value for Ethiopian and sub-saharan Africa of the total and per caput consumption of total milk over a period of 12 years. During this period, per capita consumption of milk in Ethiopia was equal to the average for the sub-Saharan Africa, with substantially higher annual growth rate. in the 1990's, although the total demand for milk and milk products increased as a result of population increase, per capita consumption has dropped in Ethiopia as result of so many factors. This has been recently demonstrated in a study on dairy production and consumption in Addis Ababa undertake by the Agricultural Bureau of Region 14 Administration.

Although not exhaustive, current prices of locally produced and imported milk and milk products in Addis Ababa are presented in Tables 7 and 8, and some special imported diary products such as blue cheese sale up to 300 Birr/kg. Importation of milk and milk products to partially fulfil local demand dominated the dairy sector in the last two decades. Table 9 shows imports and values in US$ for dairy products average over 1985/87 in Ethiopia. These products were imported in the forms of fresh milk, butter, dried milk, evaporated or condensed milk. Table 10 reveals that annual growth rate for exports diminished and imports increased in total milk over a period of 12 years (1975-1987).

Table 5. Urban human population in major towns in Ethiopia

| Town | Population | | Total |
|---|---|---|---|
| | Male | Female | |
| Addis Ababa | 1,026,900 | 1,084,600 | 2,111,500 |
| Dire Dawa | 86,249 | 87,339 | 173,588 |
| Gondar | 69,271 | 77,506 | 146,777 |
| Nazareth | 62,789 | 68,799 | 131,585 |
| Harar | 53,871 | 55,799 | 109,670 |
| Mekele | 50,314 | 57,357 | 107,671 |
| Jimma | 53,568 | 53,274 | 106,842 |
| Dessie | 50,697 | 56,013 | 106,710 |
| Bahir Dar | 48,378 | 54,322 | 102,700 |
| Awassa | 31,441 | 31,502 | 62,943 |
| Nekemt | 25,785 | 26,628 | 52,413 |
| Arba Minch | 18,899 | 18,529 | 37,428 |
| Total | 1,578,159 | 1,671,668 | 3,249,827 |

Source: Ethiopian Statistical Abstract, Central Statistics Authority, 1990

Table 6. Total and per caput consumption of total milk 1975-1987

| Countries/ region | Consumption | | Annual growth rate (%) | |
|---|---|---|---|---|
| | Total ('000MT) | Per caput (Kg/year) | Total | Per caput |
| Ethiopia | 1,101.0 | 25.6 | 3.8 | 1.7 |
| Sub-Saharan Africa | 11,546.0 | 26.7 | 3.6 | 0.2 |

Source: Handbook of African Livestock Statistics, ILCA, 1993.

After liberalization of the economy, more diversified imported dairy products have become available in the market. Local products are limited to fluid milk, butter, ghee, yogurt, and few types of cheese. Most of these milk products are produced in small household processing units and are not standardized. In most instances, producers complain about low consumer price of milk and milk products. On the other hand, the survival of the indigenous dairy industry in a competitive international market is a serious concern.

Table 7. Prices of milk and milk products in selected markets surveyed in Addis Ababa in 1997 (in Birr)

| Supermarket | Milk (liter) | Cream (kg) | Yoghurt (kg) | Butter (kg) | Ayib (kg) | Cheese (kg) |
|---|---|---|---|---|---|---|
| 1 | 3.00 | 16.00 | 6.00 | 35.00 | 6.00 | 25.00 |
| 2 | 3.00 | 20.00 | - | 32.50 | 7.00 | 35.00 |
| 3 | 2.30 | - | - | 30.00 | 8.00 | 35.00 |

Source: Abebe Tessema, personal communication

Table 8. Prices (Birr/kg) of imported milk and milk products in Addis Ababa in 1996/97

| products | prices |
|---|---|
| Milk | 13-20 |
| Powder milk | 36-91 |
| Cheese | 30-60 |
| Butter | 35-68 |

Source: Abebe Tessema, personal communication

Table 9. Imports and values for dairy products averaged over 1985/87 in Ethiopia

| Items | Volume (MT) | Value ('000 US$) |
|---|---|---|
| Fresh milk | 2.0 | 1.0 |
| Butter | 10,278.0 | 3,176.0 |
| Dried milk | 168,963.0 | 19,640.0 |
| Evaporated/condensed milk | 3,429.0 | 1,468.0 |
| Total milk (Liquid milk equivalent) | 183.0 | 24,000.0 |

Source: Handbook of African Livestock Statistics, ILCA, 1993.

Table 10. Annual growth rate for exports and imports of total milk in Ethiopia, % 1975-1987

| Category | Volume | Value |
|---|---|---|
| Exports | -11.1 | -1.7 |
| Imports | 25.5 | 21.1 |

Source: Handbook of African Livestock Statistics, ILCA, 1993.

## 5. The Addis Ababa scenario

A recent survey undertaken by the Addis Ababa (Region 14) Agriculture Bureau in 1996 shows that there are a total of 25 Kebele farmers associations and 25 Woredas within the city. A total of 5,167 small, medium and large dairy farmers out of which 4,825 are small farms. The different categories of farms and their relative production are shown in Table 11.

The major source of milk to the Addis Ababa city are a) private farms with improved genotypes of animals, b) the Dairy Development Enterprise (DDE) farms and milk collection centres, and c) smallholder dairies around Addis production using indigenous animals. The total milk production from these 5,167 dairy farms amounts to 34,649,450 liters per annum. Out of this, 73% is sold, 10% is left for household consumption, 9.4% goes to calves and 7.6% is processed mainly into butter and ayib. Farms owned by DDE produce 2,327,854 liters of milk per year, while the enterprise collects 2,185,771 liters of milk per year from smallholder farms around the city. This totals to 4,513,625 liters per annum. Of the total, 4,123,035 liters is pasteurized and sold as fluid milk, while the difference of 390,590 liters is processed into butter, ayib, cheese, cream and yoghurt. The census shows that a total of 37,426 local and crossbred cows are available within the region. The number of indigenous cows is estimated at 9,177 (20%), and 6,420 lactating cows produce 4,686,600 liter per annum. There are also 27,249 (46.5%) crossbred animals and 9,493 (34.8%) are lactating with an annual milk production of 34,649,450 liters.

The total amount of milk available to Addis Ababa is therefore 43,849,675 liter per annum. Considering the total population of 2.3 million in Addis Ababa, the per capita consumption is 17.5 liters. However, considering milk that goes into calves, the total milk available will be 36,771,957 liters and this will further reduce the per capita consumption to 16 liters. Considering a minimum consumption of 250 ml per head per day (82 liters per year), a minimum total of 207 million liters will required per year to satisfy the demand. This shows a minimum demand-supply variance of about 170 million liter per year. Moreover, given a total urban population of 4.9 million people, about 421 million liters of milk will be required per year in order to satisfy the urban demand.

Table 11. Different sizes of dairy farms and their proportional representation and milk production levels in Addis Ababa

| No. Milking Cows | Status | Percentage of total | Percentage milk production |
|---|---|---|---|
| 1-5 | small | 93.4 | 65.7 |
| 6-10 | medium | 3.9 | 12.1 |
| Above 10 | Large | 2.7 | 22.2 |

Source: Agricultural Bureau, Region 14, 1997.

## 6. The national scenario

On a national scale, the human population in major towns other than Addis Ababa is estimated at 1,138,327 people (Table 2). Considering a minimum consumption of 250 ml per head per day (82 liters per year), a minimum total of 93.5 million liters will required per year to satisfy the demand. Moreover, given a total urban population of 3.3 million people, about 271 million liters of milk will be required per year in order to satisfy the urban demand at a rate of 250 ml per head per day. For curiosity reason, using the per capita consumption of 300 liters in the United States, the estimates will be 990 million liters of milk per annum to satisfy the 3.3 million total urban inhabitants. By the year 2000, out of the expected 65 million human population, about 18% (11.7 million) is projected to be urban dwellers and by the year 2020 this number will increase to 39 million. Assuming the same minimum consumption of 250 ml per head day, there will be a demand for 3.29 billion liter of milk per annum.

Let's assume the following hypothetical situation. Given the current daily average milk production of 1.17 and lactation length of 190 days, a cow produces 222.3 liters per lactation. Currently, the estimated national figure for milking cows is 8,929,410 head. Assuming that these figures and values remain constant, then the total annual milk production will only be 1.98 billion liters. Out of this, on average 28% is converted to butter, leaving only 55 million liters of fluid milk for consumption. The demand-supply variance would therefore be estimated at 2.74 billion liters of milk year.

A report by ILCA (ILCA,1993) showed that if demand for fluid milk alone are to be met, production should grow by 4% annually until the year 2025. To fulfil the growing demand for milk and milk products, subsistence production is no more becoming the ultimate goal. Currently a number of urban and per-urban dairy farms are the major suppliers of milk and milk products to the urban consumers. Urban dairy farms, although are currently important players in the business, limitations of land and other resources, and environmental and social concerns are putting a lot of pressure on these farms. The continuation and expansion of urban dairy production system in big urban centres is unlikely.

On the other hand, large commercial private dairy production system in peri-urban areas is emerging as one of the most important market-oriented production systems in Ethiopia. These farms are located around big cities which are large consumption centres for milk and milk products. The number of such farms is currently increasing. These farms are characterized by different levels of intensification. The system is increasingly faced with the challenges of increasing total milk output and higher milk production per cow. The avenues for increasing milk production in these systems involves the use of high grade dairy animals and improved and higher levels of and economical feeding and management. The farms are characterized by the use of dairy animals of different exotic blood levels, adoption of improved feeding systems, veterinary services, provision of housing and other services to their animals, etc.

## 7. Prospects for peri-urban dairy development

The substantial demand-supply variance in milk and milk products for the major urban centres in Ethiopia shows the untapped potential for the development and flourishing of peri-urban dairy farms. Large commercial and smallholder peri-urban dairy production systems have tremendous potential for development and could play a significant role in minimizing the acute shortage of dairy products in urban centres. Market-oriented smallholder dairy production systems could be one of the avenues towards agricultural intensification. These farms could also play a pivotal role in providing good quality and diversified dairy products at acceptable prices and may eventually contribute to minimize importation of milk and milk products, currently estimated at about 24 million US$ per annum. Integration of well managed dairy production systems on smallholder farms could also contribute to improvement in household nutrition and health, family income, food security and natural resource management through efficient and effective nutrient cycling. These systems have to develop and flourish as quickly as possible and need to be environmentally sound to ensure sustainability. However, some of the major constraints to the development of per-urban dairy systems need to be given due attention and are highlighted as follows.

## 2. Major constraints for the development of peri-urban dairy

The major limitations for the development of the livestock industry in general have been dealt with similar presentations by Abaye et al. (1989) and Goshu et al. (1989). Most of the points raised in this presentation are still valid today. Some of these constraints hold true now and need to be addressed to ensure the development of peri-urban dairy production systems in the country. The government has put food self-sufficiency as a priority with rural based industrialization as a strategy. In order to effect the envisaged changes in crop agriculture, a number of government organizations and private agencies are providing support and services to farmers. Some of these support and services available for increasing crop production are presented in Table 12 with a parallel comparison of support and services required for the improvement an development of the livestock sector.

Table 12. Comparison of inputs required to improve cro and livestock production

| Crop | Livestock |
|---|---|
| Land | Land |
| Improved seed | Improved genotype |
| Fertilizers | Feed resources |
| Pesticides | Veterinary services |
| Preservation and Storage | Preservation and storage |
| Processing | Processing |
| Marketing | Marketing |

The above listed support and services available to increase crop production are provided to the farmer in various forms. However, the livestock sector has not been given it's fare share and as such the major constraints to improve the sector have not been adequately addressed. These constraints, although not exhaustive, are summarized below, with due consideration to the current policy and economic environment.

9.1 **Policy and socio-economic issues**

- Land ownership and land rights
- Dairy policy
- Price policy
- Import regulation
- Marketing systems
- Infrastructure
- Information system
- Credit facilities
- Incentives (input/output)
- Environment issues
- Quality control and public health issues

9.2 Institutional

- Research
- Education and training at different levels and in various fields
- Extension and consultation
- Dairy co-operatives

9.3 Technical and Technological

- Animal genetic resource
- Feed resource development and feed markets
- Nutrition and feeding systems

- Animal Health and diseases
- Management
- Preservation and Processing
- Technical support systems
- Qualified human resources
- Technological inputs

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# The Status of Poultry Research and Development in Ethiopia

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## Abstract

In Ethiopia, poultry have a tremendous potential for meeting the animal protein requirements of the population. Chicken are the most important type of poultry raised in the country. Poultry production is conducted mainly under two systems of management; namely the rural (village) production system and relatively advanced commercial system. A third system of production, i.e small scale family based intensive production system is coming up mainly in urban and peri-urban areas. Research and development work on poultry have been conducted by different institutions in the country for more than 40 years without adequate coordination of efforts. This paper describes the production systems. Present activities and past achievements of Institutions involved in poultry research and development are briefly outlined. Recommendations for the future development of the industry are also forwarded.

## 1. Background

High level agricultural education, research and extension started in Ethiopia in the early 1950's at the Jimma Agricultural Technical School (JATS), and the Alemaya College of Agriculture (ACA), under U.S. Operations Mission (USOM), Ethiopia. Agricultural projects and the first four agricultural experiment stations (Jimma, Alemaya, Debre Zeit and Shashemene) were established. Poultry was one of the programs started at the time. Four breeds of exotic chicken (Rhode Island Red, Australop, Newhampshire and white Leghorns) were imported from Kenya, Denmark and the United States to Jimma and Alemaya in 1953 and 1956, respectively. Trials and experimental work in the area of poultry housing, feeding, brooding, management and disease /parasite control were initiated soon after importation. The Debre Zeit Agricultural Research Center was used as a center for growing/ conditioning of baby chicks and distribution of breeding stock starting 1957 (Wiggins, 1958).

The Alemaya College and the Jimma Agricultural Technical School were responsible for rational agricultural research and extension until 1965. Ethiopia institutionalised agricultural research and extension with the establishment of the Institute of Agricultural Research (IAR) and other regional development projects starting 1966. The IAR, However, did not take up poultry research as one of its research programs. Poultry research thus far has, therefore, been undertaken only by institutions of higher learning.

Poultry research projects conducted during the early years were exploratory and dealt with the appraisal of the country's poultry population, breeds, utility and productivity. The results of the poultry research projects conducted were published as experiment station bulletins, miscellaneous publications, scientific journal articles and special reports.

The three experiment stations (Jimma, Alemaya and Debre Zeit) served as sources of improved birds and fertile eggs along with information on methods of housing, feeding, management and marketing. Poultry house and other farmstead construction designs were
distributed and/or demonstrated on annual field days. Agricultural Youth Clubs (AYC) were organized in schools and teachers training institutes. Some clubs were also formed outside schools with parents or community leaders as sponsors. In order to develop an effective youth program, extension agents were instructed to spend approximately 40% of their time on this work. An important aid to extension agents in developing youth programs was the adult youth club bulletin published monthly and distributed to the club members. It is interesting to note that 2723 bulletins and educational leaflets were distributed to 212 AYC with about 44,745 members enrolled between 1956 and 1961. It was also reported that extension agents made about 19,574 farm visits and contacted 100,136 farmers pertaining to poultry production and vegetable gardening by the year 1960 (Lee, 1960). Members of the clubs were assisted in establishing poultry projects, and were given all the necessary instructions in poultry production and management. In order to disseminate improved poultry production in the communities hatching eggs were sold from club flocks to youth club members and farmers. Surplus cockerels were also sold for crossbreeding with native hens (Herduck,1961).

## 2. The present situation

### 2.1 Poultry resources and their importance in the economy

The total poultry population in Ethiopia is estimated to be 56.5 million (ILCA, 1993). Despite the fact that 99% (Alamargot, 1987) of the poultry population are local birds, their contribution to farm household and national income is not in proportion to the high numbers. Rural poultry production represents a significant part of the national economy in general and the rural economy in particular. This segment of production represents an asset value of US $ 5.75 billion in Africa as a whole (Sonaiya, 1990), and there is no specific figure on the Ethiopian situation. The major uses and benefits of poultry and eggs in rural societies in the central highlands of Ethiopia are outlined in Table 1.

Local birds contribute 98.5 and 99.2 % to the total national egg and poultry meat production, respectively (AACMC, 1984). This amounts to an annual output of 72,300 metric tones of poultry meat and 78,000 metric tones of eggs. It is believed that the contribution of the commercial sector has increased substantially in recent years.

The per capita egg and chicken meat consumption is 57 eggs and 2.85 kg of chicken meat per annum (Alemu, 1987). This is very low by international standards . The per capita consumption of poultry meat declined to 1.35 kg in 1994 ( Poultry

International, 1997) due to the unproportional growth rates of human population and poultry products. Human population increased by about 3 % per annum over the last ten years without any marked increase in the production of poultry products.

Table 1. The major uses and benefits of poultry in the rural central highlands of Ethiopia.

| Use | eggs | Chicken |
|---|---|---|
| Hatching | 51.8 % | --- |
| Sale | 22.6 % | 26.6 % |
| Home consumption | 20.2 % | 19.5 % |
| Sacrifice (healing ceremonies) | --- | 25 % |
| Gifts | 5.4 % | 8.6 % |

Source: Tadelle and Ogle (1996a)

## 2.2 Present structure of poultry production in Ethiopia

Poultry production systems in Ethiopia show a clear distinction between traditional, low input systems on the one hand and modern production systems using relatively advanced technology on the other (Alemu, 1995). There is also a third emerging "small scale" intensive system as an urban and peri-urban household income source.

### 2.2.1 The traditional production system

This production system is characterized by small flocks, minimal inputs, low outputs and periodic devastation of the flocks by disease. Local birds are reared by individual households and maintained under a scavenging system. Flocks sizes are typically an average of 7-10 birds in each household consisting of 2 to 4 adult hens, a male bird and a number of growers of various ages (Tadelle and Ogle,1996a). The AACMC (1984) gives a national average of six indigenous birds per household. The average flock size in Africa ranges from 5-10 birds (Sonaiya, 1990).

### 2.2.2 Commercial systems

#### 2.2.2.1 Large-scale

Modern poultry production in Ethiopia started about 30 years ago, mainly in colleges and research stations. The activities of these institutions focused mainly on the introduction and distribution of exotic breeds to farmers with management, feeding, housing and health care packages. Today a number of large commercial state farms established. Private poultry farms are also starting to operate. Commercial farms with annual capacities of about 35,000 layers and 208,000 broilers are currently operating

in and around Addis Ababa.

#### 2.2.2.2 Small-scale intensive system

Under this system, small numbers (usually 50 to 500 birds) are produced along commercial lines. This system of production is a newly emerging system in urban and peri- urban areas in and around Addis Ababa. Exotic birds (mostly broilers) are raised using relatively modern management methods. This activity is being under taken as a source of income especially by ex-soldiers in towns like Debre Zeit. Most of these producers obtain day old chicks and feed from larger producers.

## 2.3 Feed resources

### 2.3.1 Ingredients available

A wide range of ingredients suitable for poultry feeding are available. Ethiopia is a country where practically every crop can be grown in one part or another providing various alternatives. A variety of grains and protein sources are available. Pulses, molasses, salt and limestone are also available locally. The only materials which have to be imported at the moment are the micronutrient supplements and the essential vitamins.

### 2.3.2 Mixed feed production

Prepared feeds are available from feed mills largely concentrated in and around Addis Ababa. These include those owned by the feed processing enterprise, private feed mills and feed mills owned by other government agencies. None of the feed mills have pelleting facilities which is a serious disadvantage for an efficient production of especially broilers. The following table gives a listing ( may not be exhaustive) of feed mills in and around Addis Ababa.

Table 2. Feed milling capacity in and around Addis Ababa

| Mill | tons/hr | Location | Mill | tons/hr. | Location |
|---|---|---|---|---|---|
| Kality feed Plant | 8 | Kality | FVM | 1 | D.Z |
| Akaki | 2 | Akaki | Almaz | 1 | D.Z |
| Ex-soldiers | 1 | D.Z | Getachew/Assefa | 2 | A.A |
| Zenata | 1 | D.Z | DDE | 1 | A.A |
| Bora | 1 | D.Z | Sululta(Mekonnen) | 1 | Sululta |
| DZARC | 1 | D.Z | Ginchi feed mill | 1 | Ginchi |

Source: Personal observation (unpublished data)
D.Z = Debre Zeit; FVM = Faculty of Veterinary Medicine; DDA = Dairy Development Authority A.A = Addis Ababa.

All these feed mills are currently operating much below their respective capacities. All operate at a maximum of only one shift of eight hours per day. It can, therefore, be seen that there is a potential of at least tripling the production by working three shifts. Feed mills are concentrated in and around Addis Ababa. This needs to change in the future.

### 2.3.3 Feed quality

The quality of mixed feed used is generally poor. Most formulations available do not have vitamin/mineral premixes (Alemu and Guenther, 1992). Ingredients vary in nutritive value and there is no quality control. Unavailability of laboratory facilities for the chemical analysis of ingredients and prepared feeds also contributes greatly to the poor quality of feed.

### 2.3.4 Feed cost

Feed cost varies from place to place. In many instances, the cost of mixed feed doesn't seem to follow reductions in ingredient cost. Prices of mixed feed remain unduly high even at times when the price of the major component of mixed rations, corn, was below 40 Birr/ quintal.

## 2.4 The disease situation

The major causes of economic loss on commercial farms are coccidiosis, Newcastle disease and respiratory diseases (Alamargot, 1987). Mortality in local birds results mainly from predators and Newcastle disease. According to the AACMC (1984), overall losses from diseases in commercial farms are not as would be expected when compared to commercial flocks in other developing countries.

# 3. Past activities in poultry research and development

Comparatively little research and development work has been carried in Ethiopia out on village chicken despite the fact that they are more numerous than commercial chicken. Upgrading and crossbreeding with exotic germplasm has been the main focus of research and development organizations. No attempts have been made to evaluate the performance of exotic birds under local farmer conditions.

## 3.1 Extension

Poultry extension had been promoted by institutions of higher learning, the Ministry of Agriculture and, more recently, by NGO's. The extension system used to promote schemes in which cockerels from selected strains were reared up to 15 to 20 weeks of age and exchanged for local cockerels owned by rural subsistence farmers. Distribution in other forms such as pullets and fertile eggs have also been practiced. In addition, improved hens were introduced to boost egg production in co-operative based intensive poultry farms in rural Ethiopia. However, this approach led to only limited improvement due to the high mortality rate because of lack of adaptation to

the rural environment and poor management practices. Ultimately the program was discontinued as it was planned without farmer participation.

Recently, the Ministry of Agriculture has launched a scheme of distributing five pullets and a cockerel to individual farmers with intensive extension follow up and supply of some inputs. Researchers at the Debre Zeit Agricultural Research center are monitoring the performance of these birds in the vicinity of Debre Zeit in collaboration with the Ministry.

## 3.2 Research

### 3.2.1 Characterization of the production systems

Characterization of the poultry production systems in the central highlands has been done recently by Tadelle and Ogle (1996a). They identified the following situations which characterize the system:-

- Total output of scavenging birds is low.
- High chick mortality represents a major loss. Newly hatched chicks have access to the same feed resource base as stronger and more vigorous members of the flock, but are unable to compete. In addition, the low protein and energy content of the available feed, the low hatching weight of the chicks, high ambient temperatures and other associated factors are major causes of losses, both directly, and also by increasing vulnerability to predation and susceptibility to diseases.
- The high chick mortality leads to practically all eggs being incubated, which in turn limits the production of eggs because of the hen's unsuccessful hatching and rearing.
- The brooding time of the mother bird is long. It is indicated that the reproductive cycle consists of an average of a 10 day laying phase, a 21 day incubation phase and finally a 56 day brooding period under scavenging conditions.
- Overall, the system is quite productive in relation to the very low input levels
- Disease (mainly Newcastle disease) was cited as the most important problem by most members of the community. Newcastle disease is more widespread in the rainy season.
- The scavenging feed resource base (SFRB) for local birds is variable depending on the season and rainfall. So, strategic supplementation of birds according to age and production status can be a suitable solution
- The SFRB for local birds in the villages is inadequate for the production of more than around 40 eggs /bird/year.

### 3.2.2 Husbandry and management

Based on the results of an on-farm trial in the central highlands of Ethiopia, vaccination against Newcastle disease, improved feeding systems, regular provision of water and small night enclosures for scavenging birds resulted in improved production.

Different designs of poultry houses were tested at Debe Zeit and recommendations made. Recently, a cage for 20 layers ("the 20-hen unit") has been developed for production of layers under situations of space shortage.

A home-made hay-box brooder in which no artificial heat is required has been tested at the Jimma College of Agriculture to reduce chick losses during brooding. According to Solomon (unpublished data), on-station results showed that batches of up to 70 day old chicks could successfully be raised (brood). There were no significant differences between the groups of chicks raised in the hay-box brooder and in an electric brooder house in terms of percent mortality, rates of growth, and rates of egg production during the laying period.

In an attempt to determine the best time of year for raising chicks in the Jimma area, the period between February and April was found to be the best for hatching chicks to obtain good survival rates (Wiggins, 1956).

Various litter materials (sawdust, teff straw, wheat straw, coffee hulls and ground corn cobs) have been compared for their suitability as broiler litter. The results indicate that corn cobs, teff and wheat straw were the most suitable (Berhanu, 1995).

### 3.2.3 Nutrition and feeding

#### 3.2.3.1 The rural production system

Research on the nutrition and husbandry practices of rural poultry have received little serious attention. One attempt was an on-farm trial in the central highlands of Ethiopia with local laying hens by Tadelle and Ogle (1996c). It has been calculated that scavenging birds are usually capable of finding feed for their maintenance requirement and to support production of about 40 eggs per year. Higher levels of production thus require supplementary feeding. An experiment conducted to determine the performance of scavenging Leghorn layers supplemented with increasing levels of a commercial ration conducted at Jimma indicated that egg production of about 200/hen per year could be obtained by supplementing 90 g/ hen /day (Solomon, 1997). According to Tadelle and Ogle (1996c), it is possible to attain hen-day production of about 30 % by supplementing 30 g maize plus 30 g noug cake; 28 % from 30 g maize only and over 20 % from 30 g per day per bird noug cake supplementation, respectively. This was more than double the 13.9 % from scavenging only.

The nutritional status of local laying hens from chemical analysis of crop contents, assuming this accurately reflects the feeds consumed, indicated that crude protein (9.1%) was below the requirements (11.3 g/day CP) for optimum egg production indicating the importance of supplementation. The deficiency was even more serious during the short rainy and dry seasons, when the CP content of the crop contents was 7.6 % and 8.7 %, respectively. From the results of Solomon (1997), it was concluded that protein supply may be critical, particularly during the drier months, whereas energy may be more critical during the rainy season.

### 3.2.3.2 The intensive system

Nutritional trials conducted on intensively managed chicken focused, among other things, on measuring the advantages of increasing levels of locally available feed resources in poultry rations, comparative evaluation of different feed resources and evaluation of different feed supplements in improving product quality. The studies were conducted on broilers and layers at various stages of development. Work at Jimma Agricultural Technical School indicated that riboflavin deficiency in chicks could be corrected by supplementing "Atella" (Wiggins, 1956). In an attempt to formulate low cost rations for the Jimma and Bedele regions, it was found that sweet potato could safely be included at about 10% in starter, grower and layer rations and that 20% Godere could be included in starter rations without affecting performance (Solomon, 1995).

In a trial to compare the feeding values of noug and peanut seed cakes in starter rations, chicks on ration containing 20% peanut seed cake grew faster and were more efficient than those on rations containing either 10 or 20% noug seed cake (Herduck, 1961).

## 3.2.4 Breeding and genetics

### 3.2.4.1 Breed evaluation

#### 3.2.4.1.1 local birds

Local chicken vary widely in body size, conformation, plumage color and other characteristics. Very little has been done to assess the performance of local birds under either traditional or improved conditions. Whatever little information available has generally attempted to establish the genetic potential of indigenous birds under conditions of good disease control, good nutrition and good husbandry practices.

Studies carried out at the College of Agriculture, Alemaya (Bigbee, 1965) and Wolaita Agricultural Development Unit (WADU) (Kidane, 1980) and by the Ministry of Agriculture (1980) indicate that average annual egg production of native chicken is 30 - 60 eggs under village conditions and that this could be improved to 80 - 100 eggs on station. A more recent study at the Assela Livestock Farm indicates the average production of local birds around Arsi to be 34 eggs / hen / year, with an average egg weight of 38 g . i.e. a total yearly egg production of 1.3 kgs. Feed utilization efficiency of hens is also very low (about 20 kg of poultry feed was needed to produce 1 kg of eggs). Testing the response of indigenous chicken to good housing, feeding and management at Jimma also showed that there is an increase in the production performance of the chicken with improvement in environment and management, but not to an economically acceptable level (Burley, 1957). Teketel (1986) compared the production potential under improved management conditions of five local strains from southern Ethiopia with the White Leghorn. The comparison in egg production characteristics showed that the local ecotypes had poorer rates of egg production (18 *versus* 26%), but sustained egg production at times of increased environmental temperatures. In a similar study on local chicken from eastern Ethiopia at Alemaya, Abebe (1992) found both hen-day and hen-housed egg production in local

stock to be about 70% of that achieved by White Leghorn stock. The average weight of eggs from local birds was found to be about 40g (AACMC, 1984; Abebe, 1992), which was similar to the 46 g reported by Teketel (1986). Predictably, in view of their lower rate of production, local birds produce eggs with thicker shells than Leghorns (Abebe, 1992), Fertility of eggs from local stocks was found to be higher than that from Leghorns(Teketel,1986).

Work on the meat production abilities of local chicken is also limited. The AACMC (1984) reported that local males may reach 1.5 kg live weight at 6 months of age and females about 30% less. Teketel (1986) also found that local stock reach 61% and 85% of White Leghorn body size at 6 months and maturity, respectively. Abebe (1992) reported that local birds in eastern Ethiopia attain 71.5% of the weight of White Leghorns at 6 months of age. The carcass weights of local chicken at 6 months of age was 559 g which was significantly lower than that of the 875 g found for White Leghorn (Teketel, 1986). The local stock, however, had higher dressing percentage.

Higher mortalities and morbidities have been reported among local birds than White Leghorns when raised under intensive management conditions in Awassa (Teketel, 1986), Debre Zeit (Abebe, 1987), Arsi (Brännäng and Persson, 1990) and Alemaya (Abebe, 1992).

In general, what has been accomplished so far in Ethiopia is not tangible enough to show the relative effects of genetic and non-genetic factors on the performance of the local chicken and to design appropriate breeding strategies. Smallholder poultry production using unimproved stock can, however, be an appropriate system with low input levels that makes the best use of locally available resources and hatch their egg and brood chicks which are important traits since our farmers are not ready to use incubators, brooders and expensive concentrate feeds yet.

### 3.2.4.1.2 Exotic birds

A comparative study on the egg production performance of six different exotic breeds, namely: Brown Leghorn, White Leghorn, Rhode Island Red, New Hampshire, Light Sussex, and Barred Rock was carried out at the Debre Zeit Agricultural Research Center (DZARC, 1984). Egg production, hatchability and mortality data were collected and evaluated over several years. The White Leghorn was rated the best in terms of egg production, adaptability, disease resistance and efficiency. In an experiment conducted to compare the adaptability and productivity of exotic breeds at Alemaya in the 1950's, all the breeds imported performed well. However, the White Leghorn had the best egg production record with less feed per dozen of eggs. White Leghorn pullets under good management could be expected to lay approximately 200 eggs/ year (Lee, 1960). Reports on the growth performance of the White Plymouthrock and the White Leghorn from the Debre Zeit Research Center indicates that White Plymouthrocks can attain an average body weight of 3 kgs at the age of 12 weeks. According to a report by Abebe (1992), White Leghorns attained weight of 1.3 kg at six months of age. Teketel (1986) reported a mean weight of 1.66 kg at the same age at Awassa. Production capacity of two exotic breeds ,namely White Leghorn(WL) and Yarkon (Y) was tested and compared with local (L) hens at Assela and the following results were obtained. Based on this, the Yarkon was

recommended as a good egg and meat producer.

Table 3. Productivity of two exotic breeds and their crosses with local hens at Assela

| Parameter | WL | Y | L | Crosses Y x L (50%) | Crosses Y x L (75%) |
|---|---|---|---|---|---|
| Wt. (kg) at 5 mo. | 1.05 | 1.2 | 0.71 | - | - |
| Mature wt.(kg)-hens | 1.4 | 1.5 | 1.2 | 1.4 | 1.5 |
| Mature wt.(kg)-cocks | 1.7 | 2.5 | 1.5 | - | - |
| Egg prod./hens/year | 167.0 | 160.0 | 32.0 | 129.0 | 114.0 |
| Average egg wt.(g) | 58.0 | 61 | 39.0 | 48.0 | 53.0 |
| Egg prod. (kg/hen/year) | 9.6 | 9.8 | 1.2 | 6.1 | 6.0 |
| Mortality, chicks (%) | 12.0 | 53 | 93.0 | - | - |
| Mortality, mature (%) | 11.0 | 14 | 34.0 | - | - |

WL=White Leghorn; Y=Yarkon; L=Local
Source: Brönnöng and Persson (1990)

### 3.2.4.1.3 **Crossbreeding studies**

Another option to improving productivity is to "upgrade" native birds, usually by the introduction of cocks, pullets and fertile eggs of imported high egg producing strains. A great number of husbandry problems have been encountered in implementing these upgrading schemes, mainly the problem of ensuring that all village male birds are removed and, more importantly, the fact that the introduced high grade animals cannot cope with the harsh environment of the village. Evaluation of the egg production performance of crossbreds involving crossing local birds with White Leghorns with different exotic blood levels conducted at Debre Zeit showed that the annual egg production of the 50% and 62.5% crosses was 146 and 193 eggs, respectively (DZARC, 1991). Overall performance including egg production, the 62.5% exotic crosses were better than either the native or exotic parents under the prevailing conditions of production. In a crossbreeding trial carried out at Assela (Brönnöng and Persson, 1990), it was observed that crossbred hens almost entirely lost their broodiness. Some started to brood but left the eggs after a few days. In terms of egg production, 50% crosses were found to be better than 75% crosses (Table 3).

### 3.2.5 **Diseases**

Studies on poultry diseases are mainly those conducted by students of the Faculty of Veterinary Medicine as part of their theses research work. Most of this work is on parasitology. Survey work to identify the prevalence of diseases were carried out at various times. In the traditional system, Newcastle disease is identified as the major killer. The Australian $V_4$ feed supplied vaccine was tried on- station and on-farm through the FAO rural poultry project by the NVI with promising results. The

development of this new heat tolerant vaccine that can be administered via the feed opens up the possibility of significantly reducing mortality in village poultry, which should make producers more positive towards genetically improved birds and inputs to improve feeding and housing. A number of other diseases including many internal and external parasites have also been reported. Postmortem examination of local birds in southern Ethiopia revealed the presence of six species of tapeworms, eight species of roundworms and two species of flukes (Tegene, 1992). Alamargot (1987) reports the presence of the following important diseases: coccidiosis, chronic respiratory disease, Marek's disease, Salmonella pullorum and deficiency diseases on commercial farms.

## 4. Major constraints in poultry research and development

Poultry research and development in Ethiopia is faced with many constraints. An overview of the major ones is given in the following section.

### 4.1 Feed availability, quality and cost

Regular availability of good quality ingredients and a fully balanced complete ration is essential for efficient poultry production. The supply of grains, especially corn, is improving due to the increase in the production of corn in recent years. The most serious problems arise from the unavailability of micro-nutrients; vitamins and minerals. Because of supply difficulties, most intensive farms do not include micro-nutrients in their ration formulations. Stocks of soluble vitamins are available in retail outlets, but are very expensive to be used regularly on commercial farms. Quality standards for some poultry feed ingredients and formula feeds are available but there is no organized system of controlling their quality. Problems associated with feed quality can be seen from sub-standard productivity of poultry on many farms. Lack of laboratory facilities, even for the basic chemical analysis of ingredients and mixed feeds, is another serious problem. Previous work indicates that there could be considerable variation in the nutritive quality from batch to batch (especially oilseed cakes) according to the origin of the material. Allowance for this can only be made with adequate analytical laboratory facilities. It has also been demonstrated that pelleted feed is essential for commercial broiler production as the benefits in terms of improved growth and feed conversion far exceed the slightly increased cost of pelleting. There is no pelleting machine in operation in Ethiopia at present. The price of feed varies according to the source of supply and region. Little attention is given to the least cost formulation of rations. It is believed that considerable scope exists to reduce the price of feed in some areas without reducing its nutritive value. Transport costs add significantly to the cost of feed in areas distant from the source of supply. The lack of feed mills and dependence on supplies of some ingredients from Addis Ababa and its surroundings add to the overall cost of feed in many parts of the country. The absence of bulk delivery services and bulk storage facilities increases feed costs. In some cases, further wastage occurs due to weevil infestation. The shortage in the supply of protein supplements of animal origin has made the price of abator by-products to shoot-up.

### 4.2 Diseases

One of the main factors that impairs poultry production is diseases. The current mortality rate from egg to adult as a result of diseases is estimated between 20 and 50% (Alamargot, 1987). During some periods of epidemics, mortalities as high as 80% have been recorded. To this burden must be added the loss of production in sick birds. Recurrent outbreaks of New castle disease at similar frequencies, usually once or twice a year, exhibit the endemic behaviour of the disease in village poultry populations.

### 4.3 Lack of statistical information

Very little data are available on poultry in Ethiopia. It is very difficult to formulate policies and undertake improvement programs without sound statistical information. There is a dire need to conduct surveys and gather statistical data relevant to the poultry industry.

### 4.4 Cultural constraints

Ethiopians are used to consuming poultry in the form of "Doro Wot" which is an expensive way of preparing poultry for consumption. Many families can, thus, consume poultry only during special occasions which reduces the demand for poultry.

### 4.5 Transport

Households in Ethiopia are found dispersed resulting in serious problems of marketing. The long distance involved in collecting and transporting eggs to the final market place inevitably results in a deterioration of quality. Lack of road networks to serve particularly rural communities also limits effectiveness of vaccination programs, acquisition of stock and feed and dissemination of other technologies through the extension service.

### 4.6 Inadequate emphasis to poultry research and extension

Poultry research has been disregarded by the major research institutions. It was and still is pursued only by researchers in institutions of higher learning as a part-time type of activity next to teaching which takes the major share of their time. Poultry keeping in most parts of Ethiopia is the responsibility of women . As reported by Tadelle and Ogle (1996a) in the central highlands, it is the women that look after the birds, and the earnings from the sale of eggs and chicken are often their only source of cash income. It is, therefore, important to actively involve women in the process of poultry improvement. This has not been done in the past. Most of the poultry extension workers and vaccinators are men. In some parts of Ethiopia contacts between women and male extension workers could be restricted by cultural factors and information may have to pass indirectly through their husbands. Extension is a very important component of agricultural development-a linkage between research and development. To efficiently conduct extension services, the technical package must first be

available. We are very short of these packages. The pre- requisite to develop a technology is developing a strong national research capacity with a strong corps of experienced researchers. Unfortunately, until recently, livestock and poultry research has been given little emphasis. In light of our head start toward privatization and intensification of commercial farming, farmers should be provided with good and reliable extension services. Research should be prepared in advance to provide the necessary technological support.

### 4.7 Shortage of qualified personnel

The number of development agents involved in poultry extension activities is small. The situation is similar with trained and experienced researchers. Poultry management is an acquired skill which is vital to successful production. Modern poultry breeds require expert management to achieve their production potential. Management has to be taught, and above all, complemented with experience. People with the required training and experience is in critical short supply.

### 4.8 Lack of coordination

There has been little coordination among research institutions and between research and development organizations. Most research projects were based on locally perceived problems; national priorities to guide institutions and individuals in selecting research topics did not exist and there is no feedback on problems from the development sector. Furthermore, the link between research and extension is extremely weak. As of this year poultry research has been recognized as a national commodity program. For the first time, institutions involved in poultry research were invited to a meeting intended to pave the future track. It was believed by participants of this meeting that a well thought document on the future direction of the program needs to be prepared. Professionals working in different areas of poultry research and development were requested by the meeting to work out short (5 years), medium (10 years), and long (20 years) term plans in their respective disciplines and come up with working papers to be discussed at a latter meeting. This will be shaped into a program document that can serve as a guide to strengthen the research program and enable to produce results that can readily be used for the development of the country's poultry industry. The national poultry research program is established with the following general objectives:

- To increase rural and peri-urban productivity and family incomes through increased poultry production.
- To ensure a high level of food security and also to raise nutritional levels of rural and peri-urban families.

The following areas were recognized to constitute the sub-programs:-feeds and nutrition; health; breeding and genetics; socii-economics and technology transfer; processing, handling and Marketing; husbandry and Management.

### 4.9 Lack of basic facilities

Facilities (laboratory & field) for conducting poultry research are either inadequate or very old.

## 5 Recommendations

### 5.1 Strategy for poultry development

There are three possible approaches to improving poultry production in Ethiopia:-

i) improved production from traditional household birds.
ii) a semi-intensive household poultry program.
iii) fully modernized intensive poultry production.

#### 5.1.1 Improving the traditional system

The existence of poultry in the household does not necessarily imply that farmers are willing and in a position to expand poultry production. Experience has shown that intensive persuasion is needed to convince them to introduce regular watering and feeding, to clean the birds' night shelter and to take care of the young chicks, before starting any research or development program to attain the genetic potential of local birds. The first critical step in rural poultry development is, therefore, the encouragement of farmers to change their attitude towards poultry keeping. Small management changes, for example regular watering, night enclosures, discouraging hens from getting broody, vaccination against common diseases and small quantities of energy and/or protein supplementation can bring about significant improvements in the productivity of local birds (Tadelle and Ogle, 1996c). In the central highlands of Ethiopia, indigenous birds kept under semi-intensive management conditions produced 100 eggs per annum and under this system of management ten clutches of eggs were produced per year as compared to three to four under normal scavenging systems (Tadelle and Ogle, 1996c). It has also been found that there are highly productive indigenous birds. The task is to identify such breeds, to determine and, if possible, alleviate factors which contribute to variability within and between them. The selected birds can then be used for crossbreeding to improve production further. Special attention should also be paid to local sources of minerals and vitamins, although scavenging birds would normally find a significant proportion of their requirements of vitamins and trace minerals. This, however may not be the case for Ca in laying hens. In general,

- Village poultry production deserves greater attention from government, research and development organizations, and above all from rural farmers.
- Preferential access to feed by newly hatched chicks should be given through some kind of creep feeding system.
- Strategic supplementation of both protein and energy, providing small night enclosures, regular water and disturbing the broody bird results in more than 100 % increase in egg production of local birds.
- It is important to focus on working with women's groups, both to use

their knowledge about poultry production and to improve their incomes.

- On-farm and on-station trials on new vaccines for the prevention of Newcastle disease are needed, particularly the heat resistant vaccine which does not need cold chain and can be administered through feed deserves further attention.
- Genetic improvement should be introduced only when the current systems have been improved in terms of dietary supplementation, housing, controlling Newcastle disease and regular water and management and gradually change the system to semi-scavenging.

### 5..1.2 The semi-intensive household program

The other approach will be semi-intensive management where by half of what the chicken require would be provided, with the balance for them to scratch from the ground. This approach would involve small semi-intensive units using a dual purpose breed or cross. There could be 20-300 birds per unit. The birds would be confined at night in a small inexpensive portable predator - proof house. The problem of grain supplies does not arise as stock could be fed grain by-products inedible to humans. Oil seed cakes which are inexpensive and widely available should also be used. A pilot however, program would be needed to evaluate the system in the field and assess costs and returns prior to large scale recommendation.

### 5.1.3 The intensive commercial system

The fully modernized intensive approach may also be pursued since the country is moving towards self-sufficiency in cereals crop production. In the short run, it would be preferable to concentrate on broiler rather than egg production due to poultry meat bringing a higher price per kg and having a feed conversion ratio of less than 2:1, compared to greater than 4:1 for eggs. Measures to maximize the efficiency of intensive poultry production would include improved feed formulation and preparation, the use of pellets rather than mash, and improved management and disease control techniques. Production sites should be restricted to localized grain surplus areas adjacent to large urban markets.

### 5.1.4 General

- There is need for a strong effort to nurture (incubate) entrepreneurs in input sources for poultry production: feedstuff suppliers, equipment manufacturers, hatcheries, chick starting centers, pharmaceuticals, meat and egg producers, marketers, slaughter and processing plants, caterers and financial services. Cooperatives should be encouraged in an effort to involve people in production and marketing, and to develop closer links between producers, retailers and consumers of eggs and meat. In light of our head start toward privatization and intensification of commercial farming, commercial farmers should also be provided with good extension services.

- Poultry keeping in most parts of Ethiopia is the responsibility of women. It is,

therefore, important to actively involve women in the process of poultry improvement. Most of the poultry extension workers, vaccinators and key poultry farmers are men. It is important to plan poultry development projects in such a way that women participate actively as poultry advisors, extension workers and vaccinators as well as poultry farmers.

- An accurate census on the poultry population together with the identification of the different types that exist should be carried out.
- The feed quality standards set by the Ethiopian Standards Institute should be enforced.
- Extension work by home economists to change the traditional way of the consumption of poultry should be started.
- The newly established poultry research program should be given the necessary support.
- Improvement of the quantity and quality of research and extension personnel through formal and in-service training should be given due attention.
- Capacity building in terms of laboratory and field facilities to strengthen poultry research should also be given due emphasis.

## 6. Institutions engaged in poultry research and development in Ethiopia

There are a number of research and development institutions dealing with poultry production. Brief account of the activities of these institutions is presented below.

### 6.1 Alemaya University of Agriculture (AUA)

Poultry research projects were initiated at Alemaya starting from 1956. These included breed adaptability, artificial brooding methods and local mineral and vitamin sources for poultry (Canaday, 1959). The last research project initiated at Alemaya just before the termination of the contract of the U.S Operation Mission to Ethiopia was more of a demonstration type. They dealt with the designing, constructing and demonstrating of three types of poultry houses for commercial laying hens (Herduck, 1963). Initially, poultry research was conducted by the staff. Poultry research at Alemaya increased with the launching of the graduate program in 1979. Graduate students took up a number of research projects on various aspects of poultry production. A collaborative research program on poultry with the Swedish University of Agricultural Sciences has recently been started. A four credit hour course is currently offered on poultry production and hatchery management to undergraduate students.

### 6.2 Ambo College of Agriculture (ACA)

The Ambo College poultry farm was established in 1979/80 with the objectives of training and research. The farm has a capacity of 1000 chicks (brooder house), 450

(grower house), 450 (layer house). The college has recently started distribution of fertile eggs, pullets and cockerels to the Ministry of Agriculture (zonal office), NGO's and individual farmers. One new research project is proposed by the staff of the college for funding through the poultry research program.

### 6.3 Awassa College of Agriculture (AWCA)

The poultry section offers courses to regular degree and diploma students as well as to continuing education program students. Likewise, courses are sometimes offered to development agents from the Ministry of Agriculture (MOA), NGO's like Agri-service Ethiopia, Concern, etc. Besides consulting people engaged in poultry production, a total of 5,839 chicken ( 3500 day-old chicks and 2339 pullets) were distributed to government organizations, NGO's and farmers since 1986 (E.C). In addition, research activities were and are still being carried out in the section on poultry breeding, nutrition, health and management. Courses in poultry husbandry are also offered.

### 6.4 Chilalo Agricultural Development Unit (CADU)/ Arsi Rural Development Unit (ARDU)

More than 2500 cockerels were distributed in the project area up to 1989. This scheme involved removal of the local cocks and giving recommendations and instructions to the responsible household members on poultry management.

### 6.5 Debre Zeit Agricultural Research Center (DZARC)

The DZARC is one of the first centers established to conduct research and extension (initially). It was instrumental in:- the introduction of exotic egg and meat type breeds and assessing their adaptability and performance under Debre Zeit conditions; selection, propagation and distribution of the best performing breed(s); development of inexpensive poultry rations from locally available feeds; improving the colour intensity of egg yolk of exotic birds managed intensively; testing the performance of local strains of chicken and improving them through crossbreeding with exotic birds; designing low cost poultry houses for small scale producers. Courses on modern poultry husbandry were also given to farmers, women's groups, Ministry of Agriculture field staff, high school students and other interested individuals. Currently, the center is given the national mandate of coordinating poultry research in recognition of its previous contributions and the ideal position of the center to do the job.

### 6.6. Faculty of Veterinary Medicine (FVM), Addis Ababa University

The Faculty offers two courses on poultry to its students namely: Poultry production (3 credit hours) to second year students and avian pathology (3 credit hours) to fifth year students. There is no veterinarian specialized on poultry diseases in the country. The Faculty relies on a veterinarian who has taken short courses on poultry and has experience on poultry diseases through working at the poultry development enterprise farm to teach the avian pathology course. The Faculty gives professional assistance

to poultry producers in the vicinity seeking veterinary services.

### 6.7 Jimma College of Agriculture (JCA)

JCA was a pioneer in poultry research and development. Four breeds of exotic chicken (Rhode Island Red, Australop, Newhampshire and White Leghorn were imported to Jimma in 1953. Experiments on various aspects of poultry husbandry were initiated soon after importation (Wiggins, 1958). There was no research project conducted at Jimma between 1969 and 1985. In 1985, poultry research was reinitiated. Currently, there are substantial research activities going on at Jimma.

### 6.8 Ministry of Agriculture (MOA)

The MOA is the organization given the mandated for poultry extension work. A poultry expert is a member of the animal breeding, feed resources and fisheries development team at both the national and regional Ministries of Agriculture. Poultry extension activities thus far have concentrated on breed improvement through distribution of exotic breeds (111,560 cockerels and 111,834 pullets distributed between 1971 and 1983 E.C.). The Ministry has established seven multiplication centers in different parts of the country. Three of the centers are already functional (Awassa, Bedele and Kombolcha), while those at Nazareth, Andassa, Mekele and Adelle are at various stages of completion. The objectives of these multiplication centers include:-rearing and distribution of 3 month old pullets/cockerels to farmers; distribution of day old chicks to interested producers; distribution of fertile eggs to farmers; giving in-service training to extension workers and farmers; and serving as a model. Each of these multiplication centers has a capacity of 1500 parent stock, two brooder houses of 5000 day old chick capacity, a hatchery unit and a feed processing plant. When working at full capacity, these centers are planned to produce a total of 180,000 pullets/cockerels annually. Future plans include expansion of the extension activities beyond breed improvement to include feeding, health and other management aspects focusing on the following points:- facilitate the use the V-4 vaccine against NCD; anti-helminthic and coccidiostats; give feeding recommendations based on local feed resources; facilitate the gradual shift of the extensive system of production to semi-intensive system of management; organize producers associations for the purposes of easier input distribution, vaccination etc.; work more closely with women's departments for more effective poultry extension; strengthen the multiplication centers to attain their capacities; enable the feed mills of the centers to produce mixed feed for the purposes of supplying the centers and surrounding producers; establish a basic breeding farm that can supply parent stock of dual purpose breeds to the multiplication centers; establish 57 satellite brooder houses that get day old chicks from the multiplication centers, rear these chicks to 3 months of age and supply pullets/ cockerels to their respective zones.

### 6.9 The National Veterinary Institute (NVI)

The National Veterinary Institute (NVI) was established in 1939 in Addis Ababa and moved to Debre Zeit in 1963. The NVI has been fully engaged in the production of vaccines for prophylactic uses. The NVI has been producing Newcastle vaccine (live

vaccine) since 1974. An inactivated injectable oil immulsion Newcastle vaccine has also been produced since 1986/87. Experimental production of fowl pox vaccine has just started. The Institute has plans to produce Newcastle clone vaccine and fowl cholera vaccines in the future. Beside the above mentioned vaccines, the NVI produces polyvalent Salmonella pullorum antigen for testing both negative and positive S. pullorum infected fowls. Studies conducted at the NVI are primarily geared to qualitative and quantitative improvements of the vaccines produced by the institute. The NVI has so far produced 15,658,200 doses (Lasota and HBI strains) of Newcastle disease vaccine

### 6.10 The Poultry Development Enterprise (PDE)

The poultry development enterprise (PDE) is the largest commercial poultry production set-up in the country. The enterprise has farms at three locations namely: Shola, Dembi and Lemlem.

*Shola farm*:- Established in 1959 E.C. It distributed exotic genotypes to poultry producers until 1964 E.C. The farm then started improving its facilities and built up its capacity to 52,000 layers and evolved as a commercial operation.
*Dembi farm*:-Started in 1975 E.C. with a capacity of 145,000 layers, rearing unit of 250,000 in two batches and a hatchery with an annual capacity of 1.7 million chicks.
*Lemlem farm*:- Used to be a privately owned farm before it was nationalized in 1967 E.C. In 1968 E.C., six more houses were constructed and its capacity raised to 400,000 broilers per year (4 cycles of production).

The poultry development enterprise (PDE) had plans to expand its operations around Debre Zeit and start new operations in Dire Dawa, Nazareth, Awassa, Kombolcha and Bahir Dar. However, expansion of the Debre Zeit facilities was the only one realized. A complex with an annual capacity of 150,000 layers, 1.3 million layers, 2.4 million chicks and a slaughter house with a capacity of 1000 chicken per hour is in place. The enterprise is not keeping any parent stock at the moment. It imports all the chicks it needs from abroad. Production is currently far below capacity due mainly to financial problems to import large numbers of broiler chicks; ageing facilities that need maintenance and rehabilitation; inadequate supply of animal protein sources; and seasonality of market demand. The enterprise produced only 12,691,000 table eggs, 100,000 dressed broilers, 156,000 day-old chicks and 257,000 fertile eggs. Some measures of productivity of chicken at the enterprise are indicated below:-
*Broilers*:- mortality 20%; Sixty day live weight of 1.8 kg
*Layers*:- replacement pullet mortality 6-8%; start of lay 5 months of age; feed consumption /bird up to 5 months of age = 6-7 kg; production of 230 eggs/layer/year; layer mortality of 15-24%; daily feed consumption of 100 -129 g; fertility of eggs of 90%; hatchability of fertile eggs of 80%.

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# Milk Processing and Marketing Options for Rural Small scale Producers

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**Abstract**

In Ethiopia, milk is produced in all the agricultural production systems. The bulk (98%) of the milk (MOA, 1993) is produced in rural areas by peasant farmers, who do not have access to market their products at a better price. Linking the rural production to village, town and urban consumers by establishing rural milk marketing and processing units constitutes important contributions to dairy development. Improvement efforts in developing the marketing system will provide more economic advantages to smallholder dairy producers.

To improve the dairy marketing situation different options have been proposed. Some of the proposed options have been implemented by the Smallholder Dairy Development Project (SDDP) of the Ministry of Agriculture. New strategies of setting up of milk processing and marketing units under producers/peasant farmer's milk marketing groups were adopted. Farmers involved in this system have secured a regular income from sales of milk. This paper describes the activities of farmer's milk marketing groups established with the support of the SDDP.

## 1. Introduction

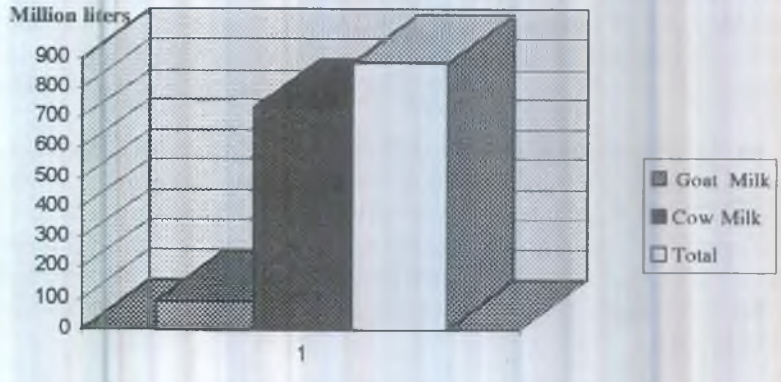
Ethiopia has a human population in excess of 56 million and is growing at an estimated rate of 3% per annum. There will be a growing demand for dairy products and farmers need to be motivated to produce more. However, poor marketing system and price structure will continue to be a constraint to progressing farmer. Rural milk production can be substantially increased if access to market can be assured.

As presented in Figure 1, the main source of milk in the country is the cow and produces 83.4% of the total annual milk output (FAO, 1993)[1]. Of the estimated 33.8 million cattle population only about 100,000 are improved genotypes (pure bred and crossbred), which constituent only about 0.3% of the total cattle population (AFRDMD, MOA, 1991).

1 camel milk is not included

Recent estimates of milk production show that Ethiopia produces about 926 million litres of cow milk per annum (SDDP, MOA, 1996). The smallholder and pastoral production systems contribute about 98% of the total output. However, only an insignificant portion of this is goes through the formal market. To improve the dairy marketing situation a one tire model has been introduced to link rural producers and urban consumers in the highlands of Ethiopia by FAO (TCP) and WFP and FINNIDA assisted Smallholder Dairy Development Projects of the Ministry of Agriculture. The model has been introduced in to specific selected sites. This paper reports on the milk marketing and processing operations of the introduced model.The report is entirely based on field experiences gained during the implementation of the project and is expected to furnish necessary information and experience for future dairy development efforts in similar situations elsewhere in Ethiopia and East Africa.

**Fig. 1 Annual estimated milk production from goats and cows in Ethiopia**




Source: FOA year book vol. 47,1993

## 2. The smallholder dairy development project

Smallholder farmers in Ethiopia represent 85% of the population and hence form an important portions of the country's population ( MOA, 1993). In recognition of the role of smallholder farmers in the development of dairying in the country, the government has, with assistance of bilateral donor agencies has established a number of dairy development projects. In relation to this, the Smallholder dairy development pilot project assisted by FAO (TCP) & WFP from 1990 to1993 and the Smallholder Dairy Development Project assisted by FINNIDA from 1995 to1998 have been involved in promoting village small scale dairy processing in addition to other dairy development activities. Village milk units (mini dairies or milk plant) were established by organising farmers in the Asela zone at Lemu and Bilalo peasant associations (Pas) and in north west Shoa zone at Edoro and Annaso PAs of Oromiya Regional State. All of them are running successfully and profitably

mainly due to strong organisational and management skills of the farmers' milk marketing groups, who are responsible for collecting, processing and marketing of dairy products. Also the introduced technology chosen by the project is low level technology which farmers can handle with confidence. There are also about six additional milk units in the pipe line to be established by SDDP in 1997 in the Oromiya, Amhara and Southern Ethiopia Regional states.

### 3. Farmer's milk marketing group

In the extension system it was agreed to make the maximum effort in establishing and operating a profitable milk unit in which smallholders organise themselves in collecting, marketing of milk to enhance their independence at a community level. A milk-marketing group can be defined as a group of smallholder farmers who individually produce at least one litre of saleable milk, are willing to form a group with the objective of collectively processing and marketing milk. Therefore the groups established in Lemu, Bilalo, Edoro and Anasso PAs are called Lemu, Bilalo, Edoro and Anasso milk marketing groups, respectively.

The idea of group work and formation of a group is not new to Ethiopian culture. Different local groups can be identified. For example, women's group called milk equib, traditional social groups like Edir, Equib for men, seasonal farming groups like Debo, etc. can be mentioned. These are various forms of groups where only interested individuals become members to deal with specific objectives. These groups have their own by-laws or regulations which assist them in managing their group activities. Such group formation is self initiated and it is not imposed from outside the society. Such systems still exist and function well in rural community.

The formation of the milk marketing groups is based on the above traditional background. Only interested and willing farmers in the PA were considered to be members of the group. At the beginning however, the establishment of milk groups took more time than thought. This was due to the fact that farmers show reservation for any form of collective ownership and co-operative work. This was as a result of the bad experiences they had in the formation of producers' co-operative, during the previous government. Formation of a group may face difficulties in areas where producers' co-operatives existed, as people would assume that such a group is a form of producers co-operative. That is why the name Group is used instead of Co-operative or Association.

We have noted that farmers' milk marketing groups are more development oriented and more sustainable than the private and other ventures that are more merchant oriented in the their outlook towards the business of milk production and marketing. Understanding of the rural set up in terms of social, infrastructural and farming systems is the key factor in forming farmers' group in the peasant sector.

## 4. Milk Collection

### The model

In this model (figure 2) a one-tier structure was adopted where both collection and processing take place at same place. Milk is collected from near by farmers and processed at the collection site using manually operated milk processing equipment, such as cream separator, butter churn, etc. The products can either be marketed at the same site or can be transported to market elsewhere. The advantage of this system is that milk is processed and converted to products of longer shelf life immediately. No electric system and cooling facilities are required in this model. A milk collection and processing unit requires an appropriate dairy building. The building used by the milk group has a maximum capacity to process 500 litres of milk per day.

It was assumed that 50% of the daily milk production is used for household consumption and 50% is used for sale. Milk produced in the morning is sold to the milk units and milk produced in the afternoon is used for home consumption and processing. Such an approach will not affect the traditional utilisation system of milk by smallholder farmers.

The marketable surplus milk per household per day varies depending on the season and the number of milking cows owned. The over all average milk delivered to the units per farmer per day is about 5 litres, and ranges from 1 to 12 liters. The milk is tested at reception using organoleptic and lactometre test for milk hygiene and adulteration. Milk is measured using graduated aluminium milk cups. The quantity of milk received daily is registered aganist the producers name. Payment is made to suppliers every 15 days based on volume

**Fig. 2 The model, one tier structure for village milk unit**

The total milk delivered to the units is shown in Figures 3 and 4. The maximum amount of milk collected per day was 200, 175, 230 and 130 litres in Lemu, Bilalo, Edoro and Anasso milk units, respectively. As it can be observed from figure 4, the quantity of milk delivered to the milk units is increasing. This is mainly because more farmers are getting involved in the sell of milk, it improves income, some are trying to improve the management and there is seasonal over flow. In addition to the normal milk supply, more milk will be delivered to the unit because of strict religious adherence to fasting periods. In Orthodox Christian dominating community, fasting periods like two days in a week, on Wednesdays and Fridays, and the long fasting seasons causes periodic over supply. The system also secures market for these periods of over supply.

## 5. Milk processing and marketing

Milk received by the unit is processed into different milk products, such as cream, skim milk, sour skim milk (locally called ergo), butter and cottage cheese (locally called ayib) (see Figures 5 and 6). Traditionally in Ethiopia, milk is accumulated for two or three days and is soured before butter making. Clay pot or calabash is used to churn the sour milk. Butter making is not a new technology to Ethiopian culture and butter is used in cooking a variety of Ethiopian dishes.Traditionally butter is good source of income for women. Although the contribution of dairy products to the gross value of livestock production is not known, a study by an ILCA (1989) showed that sales of dairy products, especially butter, contribute to 20% of the rural household income in the Ethiopian highlands.

At the milk units, cream is used for butter making and the skim milk is sold back to farmers or any other buyer or is used for ergo or ayib making (Figure 7). Unlike Edoro and Anasso milk units, fresh skim milk has a good market in Lemu and Bilalo milk units. Poor farmers who do not have a cow buy skim milk from the units for consumption and/or for further processing. In most areas of the country selling fresh milk to the poor, close relatives or neighbours is socially unaceptable. The existence of the milk units has provided opportunities for access for those who do not have a cow to buy dairy products.

Fig. 3. Ammount of milk collected and milk products produced from April 17 to Nov. 30, 1996 at Edoro and Anaso milk units

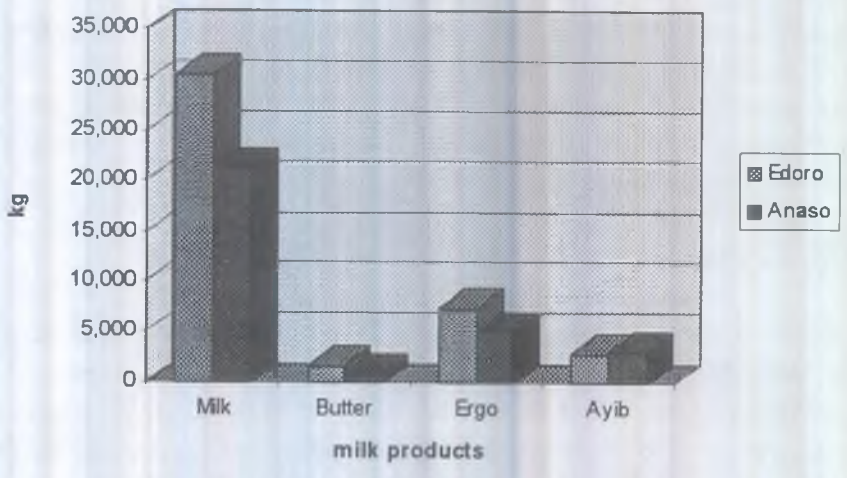



Fig. 4 Amount of milk monthly collected at Bilalo and Lemu in 1995

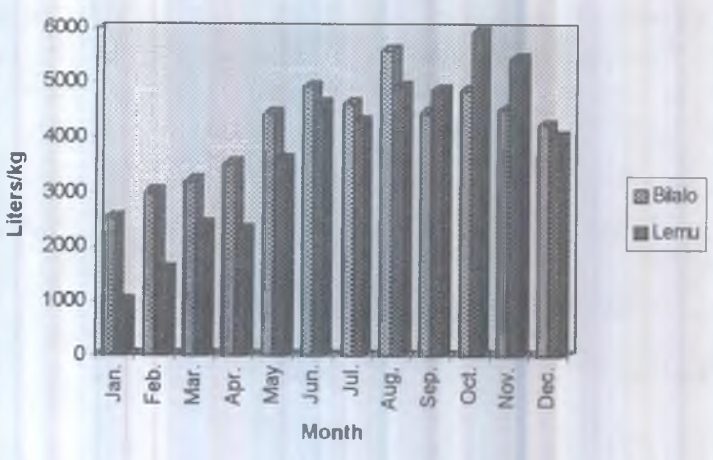


Fig. 5 Milk products produced at Bilalo milk unit in 1995

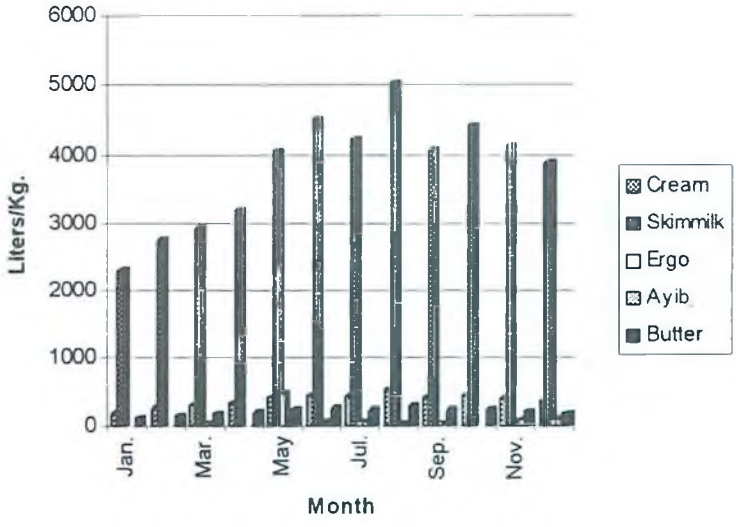



Fig. 6 Milk products produced at Lemu milk unit in 1995

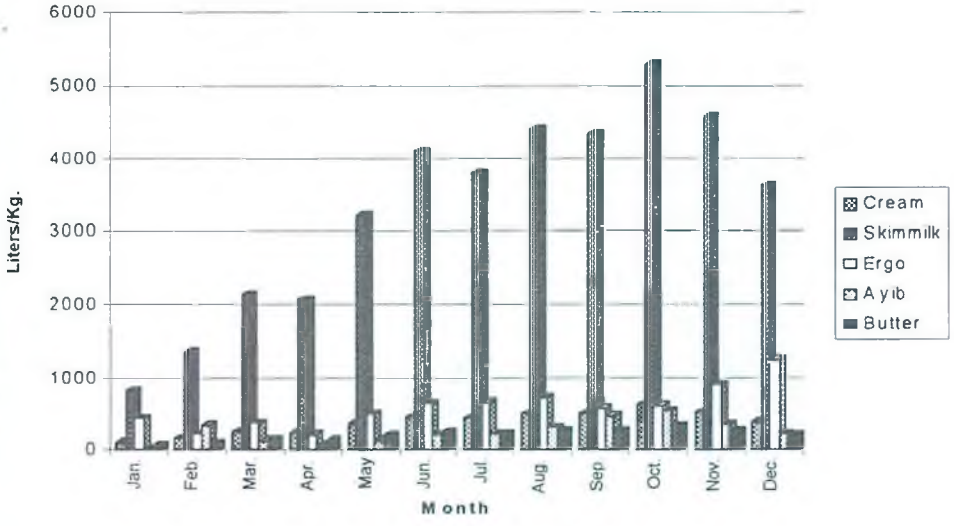
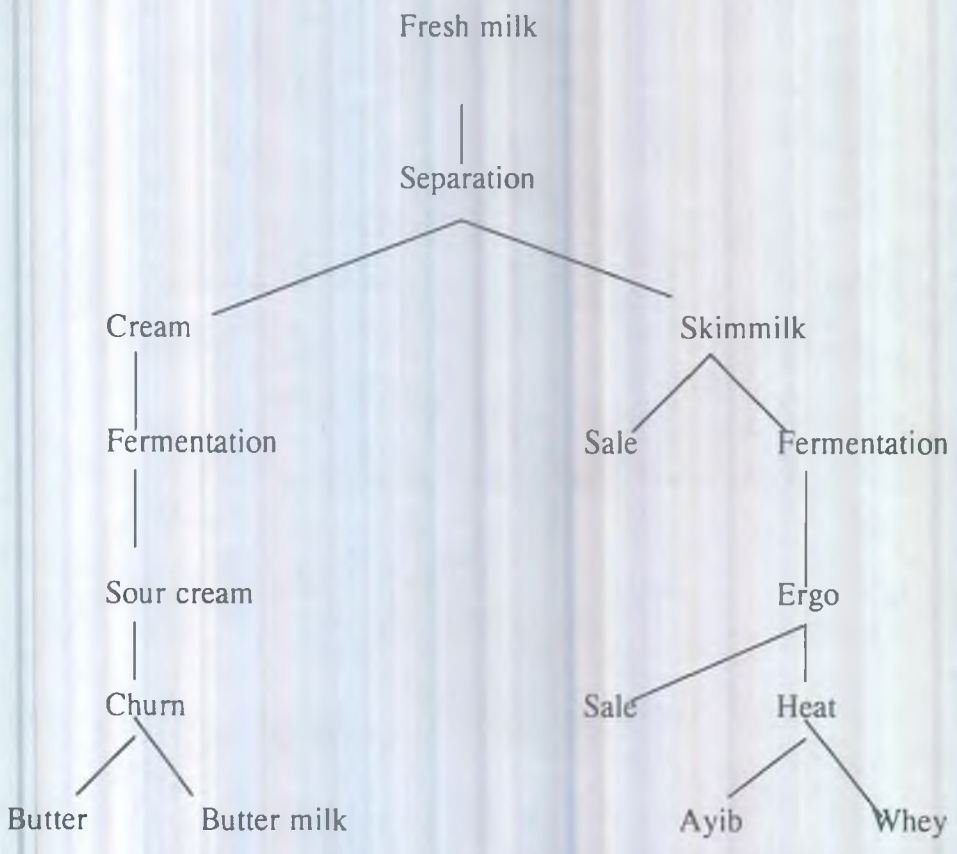


**Fig.7. Flow diagram of milk products produced at the milk units**




Milk samples were taken from the Lemu milk unit for determination of fat contents at the ILRI Dairy Technology unit, Debre Zeit station. The average fat content of whole milk, cream and skim milk were 4.7%, 59% and 0.18%, respectively.

The buying and selling price of milk and milk products varies depending on the season and there is no fixed price as such. Changes in prices is normally decided on meetings of the milk group members.

Increase in milk sales can be obtained if the management skills of the farmers is improved. The approach provides an incentive to go for better management of dairy animlas in order to be able to increase milk production and secure better farm income.

## 6. Income

Our records show that farmers supply as high as 17 litres of per day to the milk units. As it is stated earlier, the average milk delivered per farmer per day is about 5 litres. The price of milk varies from 1 Birr to 1.50 Birr per litre. If we take an average price of Birr 1.10/litre, then a farmer can earn about Birr 165 per month

from morning milk sale only. Most of the women farmers get monthly income of above the average. For example, at Edoro, according to the milk record in May, 1996, the highest milk delivered per farmer per day was 12 litres and this was supplied by a women farmer.

Edoro and Anasso collected a total revenue of Birr 40,293 and 27,340, respectively, from April 17- Nov. 30, 1996, Bilalo and Lemu earned about Birr 83,290 and 82,238, respectively for the year 1995. In 1995, the highest revenue collected in Lemu occured in the months of July, August and October (Figure 7). These values are total revenues collected (gross income) from sales of butter, fresh skim milk, ergo and ayib. Butter had the highest market value (figure. 8). More than half of the income is used to pay to suppliers or smallholder farmers for purchase of milk.

## 7. Employment

The system provided employment opportunities for family members in rural areas. In addition to the labour and time spent for managerial and marketing activities by the marketing group members, each unit has employed 3 permanent and 1 temporary workers. Out of the 3 workers, one is a milk technician trained by the project in rural dairy technology responsible for running the unit's daily operation and the other two are a cleaner and a guard. Their salary is paid on monthly bases by the respective milk marketing groups. The salary increment is dependant upon increases in milk delivered to the units. In the long run, potential increase in milk supplly to the units could provide more numbers of job opportunities.

Fig. 8 Gross income from sales of milk products at Bilalo and Lemu milk units in 1995

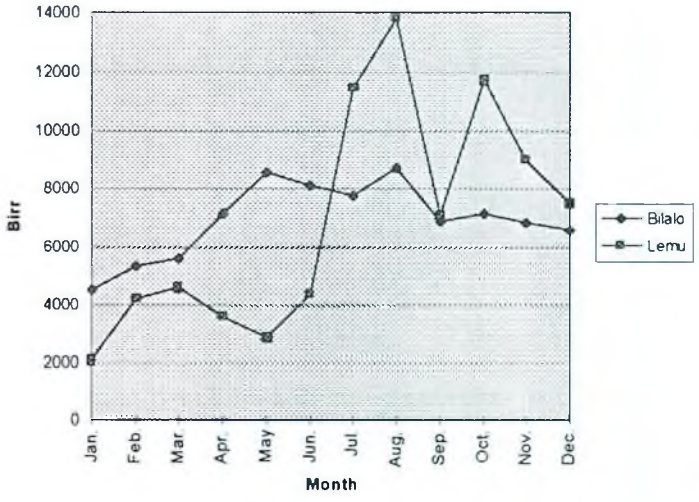
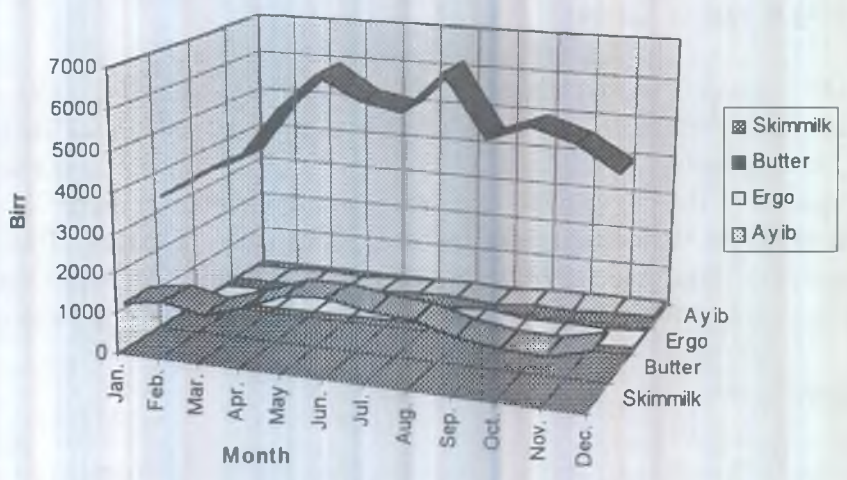


Fig. 9 Sales of milk products in Bilalo milk unit in 1995




## 8. Conclusion and Recommendations

In general, a market oriented agricultural production would secure food supply to the rapidly growing non-farming community, create employment opportunities and promote rational economic development. Marketing services are critical to national food security. The experiences shared in this report show that interventions have to be made at all levels.

Although there have been many techincal interventions to increase milk production, the attention given to marketing services has been minimal. However, to increase milk production, appropriate milk marketing and processing system is compulsory. In general, the development of improved marketing system is particularly important because increases in production is unlikely to be sustained unless the products are marketed in order to secure regrular income for farmers.

As a concluding remark, the following are recommended:

- Farmers' milk marketing groups have been identified as being essential to dairy development. Dairy farmers need to organise themselves to overcome the problems of collecting, transporting, processing and marketing of milk and milk products. Therefore it is recommended that the establishment of producers organisations should be promoted and strengthened, with a strong training and educational programmes. It is important to encourage smallholder dairy farmers to make transition from susbistencein milk production to market-oriented operation.

- Dairying, in its general term, is time consuming and labour demanding farm activity. Managment of crossbred cows demanding than that of the indigenous cows. The higher the level of exotic blood, the more time and labour input required for feeding, milking, manure disposal, processing, marketing, etc, particularly by women. Therefore, the traditional role of women in dairy operation should be considered in any rural dairy development programmes.

- The traditional cattle keepers in the pastoral areas have large herd size and produce surplus milk than the traditional cattle keepers in the highlands. This surplus milk is usally produced during the rainy season and during peak lactations. Therefore, there is an option to establish seasonally operating milk units in the pastoral areas. Although milk marketing problem seems to be more apparent in the improved dairy production system, there is still an option to improve income of cattle owners in the pastoral society from sales of milk produced from local cattle.

- In some areas fresh milk is not considered a marketable commodity due to cultural restrictions. Therefore, to expand the system to various parts of the country, the government has to demonstrate the impact of improved marketing system with the participation of producers. As the system is new to the existing dairy development extension system of the Ministry of Agriculture, government assistance in demonstrating and organizing farmer to farmer field visit training programme is essential.

- In general, dairy research in Ethiopia has largely focused in addressing issues associated with biological effiecency of dairy animals, and adaptive research which includes on-farm studies in collaboration with development or extension agencies and peasant farmers is vey limited.Therefore, considerations must be given to on-farm studies.

## 9. Acknowledgement

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# Milk Sales Outlet Options in Addis and the Surrounding Peri-urban Areas

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## Abstract

There is a scope for development of dairy farms in the peri-urban areas of Addis Ababa as there is demand for milk. Of the daily produced milk, peri-urban farmers sell 59% while intra-urban producers sell 74% of the milk produced in fresh form. The major milk outlets include immediate users, catering institutions, and the shola milk processing plant. Selection of sales outlets are based up on proximity, prices, reliability and lack of alternatives. To ensure the supply of fresh milk to the capital, construction of infrastructure, organizing dairy marketing co-operatives and encouraging private investment need special attention.

## 1. Introduction

### 1.1 General

Milk is an output of almost every agricultural production system in Ethiopia, i.e., pastoral, agro-pastoral and mixed farming systems. Specialized intensive dairy systems are found in the vicinities of urban centers. Milk produced in rural areas is usually consumed as fresh or sour milk, or processed in to dairy products with longer shelf life. It is only in the peri- and intra-urban areas that liquid milk is marketed. Organized liquid milk marketing is not well established and is limited to the surroundings of Addis Ababa. Although Ethiopian consumers use milk from cows, camels, sheep and goats, the term "milk" in this paper refers to cow milk only.

This paper describes and discusses producers' milk utilization pattern, market outlets and compares demand and supply of milk in the Addis Ababa dairy market. The study is fully intended for the purpose of indicating the scope of investment in the dairy development sub-sector.

## 1.2 Objectives of the study

The main objectives of the study are to:

- identify milk utilization patterns and sales outlets, and
- assess the demand and supply of milk.

## 1.3 Data sources

The sources of the data used in this paper include primary, published and unpublished secondary data that were analyzed using a micro- computer.

## 2. Producers milk utilization patterns

In the Ethiopian highlands, milk produced by smallholder farmers is used for family consumption, calf feeding and processing into butter and "Ayeeb", a type of cottage cheese. According to O'conner (1992), there is constant competition between calves and members of the family for liquid milk.

**Table 1. Daily milk allocation for different uses (% volume)**

| *Uses* | *Location* | |
|---|---|---|
| | Intra-urban (%) | Peri-urban (%) |
| Home consumption | 6 | 8 |
| Home processing | 8 | 20 |
| Calf feeding | 12 | 13 |
| Selling | 74 | 59 |
| Total | 100 | 100 |

Table 1 indicates that the bulk (74%) of daily produced milk in the intra-urban areas is sold in fresh form and the remaining percentage is used for other purposes. In the peri-urban areas, about 59% are sold and the balance (41%) is used for processing, calf feeding and owns consumption. The difference in the percentage of saleable milk in the two areas is a result of proximity to liquid milk market outlets. Marketed liquid milk (Mlm) is a function of total production (Tp), home processing (Hp), home consumption (Hc) and calf feeding (Cf).

Thus, $Mlm = [(Tp-(Hp+Hc+Cf)]$.

Assuming Tp remains constant, if the sum of Hp, Hc and Cf increases, the amount of milk (Mlm) supplied to the market in liquid form will decrease. However, if Tp increases, Mlm will also increase and vice versa. Therefore, there is a direct relationship between Mlm and Tp. On the other hand, the sum of Hp, Hc and Cf is inversely related to Mlm.

## 3. Milk marketing

### 3.1 Marketing Systems and Milk Sales Outlets

Debrah and Antench (1991) stated "In Ethiopia, fresh milk is distributed though the informal and formal marketing systems. The informal marketing involves direct delivery of fresh milk by producers to consumers in the immediate neighborhood and sales to itinerant traders or individuals in near by towns. The formal milk marketing system is dominated by the government controlled Dairy Development Enterprise (DDE) which ***functions as a milk producer, collector and distributor".***

Taking into account the demarcation given to the two milk marketing systems, this study looked at different outlets. Accordingly, immediate users (consumers), Shola plant, catering institutions and retailers were identified as major outlets (Table 2). As indicated in Table 2, in the intra- urban areas:

- 71.2% of the producers sold milk directly to consumers,
- 9.7% to catering institutions,
- 3.6% to retailers, and
- 15.5% to combinations of these outlets.

Similarly, in the peri-urban areas, 62.4% of the producers supplied milk to the Shola plant, 11% sold directly to consumers and 7.4% to caterers and Shola plant (DDE) and 19.2% to the combination of the outlets (Tables 2).

It was also observed that none of the intra-urban producers sold milk to Shola plant (DDE) whereas, in the peri-urban areas the DDE is the dominant milk sales outlet.

**Table 2. Percentage of farmers selling milk to different Outlets**

| Outlets | Intra-urban | Peri-urban |
|---|---|---|
| Direct to consumer | 71.2 | 11.0 |
| Shola plant (DDE) | - | 62.4 |
| Catering institutions | 9.7 | 7.4 |
| Retailers | 3.6 | 2.1 |
| DC-Catering institutions | 12.3 | 4.2 |
| DC-Shola plant | - | 9.2 |
| Dc-Retailers | 2.6 | - |
| CI-Shola plant | 0.6 | 2.1 |
| Co-operative user groups | - | 1.6 |

*Note:* DC = Direct to consumer; CI = Catering Institutions

The variation in the number of farmers using different outlets is attributable to proximity, price, reliability and lack of alternatives. In relation to this, Debrah and Anteneh (1991) reported that "producers" knowledge of alternative sales outlets and of prices they offer will, generally, enhance their bargaining position and improve their chances of getting the highest prices for their products. Producers will also have the flexibility to shift between outlets to obtain the best prices.

### 3.2 Distribution methods

In the liquid milk markets, producers usually sell at their farm gates, deliver to customer's premises or use both methods. To this end, Belachew, (1989) reported that 53% of the intra-urban producers sold milk at their farm gates, while 33% and 14% respectively delivered to customers homes and used both methods of distribution. The same study indicated that 70% of peri-urban producers delivered milk to customers premises and DDE collection points, 21% sold at their farm gates, while in the case of 9%, customers collection and producer delivery were used.

**Table 3. Percentage of farmers that selected different market outlets**

| Factors | Intra-urban | Peri-urban |
|---|---|---|
| Proximity and better prices | 48.0 | 6.2 |
| Proximity | 36.0 | 33.0 |
| Better prices | 10.7 | 16.2 |
| Lack of alternatives | 2.0 | 12.3 |
| Nearness and lack of alternatives | 0.6 | 15.4 |
| Other factors | 2.7 | 16.9 |
| Total | 100.0 | 100.0 |

***Note: Other factors include reliability and accumulated income***

## 4. Milk supply and demand gaps

### 4.1 Supply sources

Milk supply sources to Addis Ababa can be broadly divided into domestic sources and imports.

According to the milk and milk products survey report (Belachew, 1989), about 37,067 liters of milk (77%) was daily supplied by domestic sources to Addis Ababa, while 23% was imported. The same study indicated that of the domestic sources, intra- and peri-urban producers supplied 82%, while only 18% came from the DDE. The role that each source plays in the liquid milk market is discussed as follows.

### 4.1.1 Domestic sources

#### 4.1.1.1 Dairy Development Enterprise (DDE)

The DDE is the sole source of pasteurized milk in Addis Ababa. Its inputs come from smallholder farmers, commercial farms, state dairy farms and imports. Over the years 1981/92-1995/96, it processed on average 7.3 million lts. of milk/annum (Table 4) into mainly pasteurized milk and other dairy products.

The fresh milk input to the Shola Dairy Plant declined during 1982/83 to 1984/85, which was attributed to the 1993/84 drought that had mainly affected milk production in the smallholder sector. The intake again recovered and showed an upward trend in 1985/86 through 1986/87 mainly because of increased number of milk collection points and introduction of chilling centers. During the following two years (1987/88 and 88/89), it again dropped at an increasing rate. A sharp decline in fresh milk intake occurred over the year's 1989/90 to 1992/93 when annual intake dropped from 8.8 million liters to 2.2 million liters. This was attributed to milk supply shortfalls from the three sources that were affected by inadequate feed supply, lack of veterinary drugs and high mortality of herd registered, especially at the state farms.

**Table 4. Milk supply to the Shola Plant (DDE), '000 lt.**

| Year | Fresh milk | | Imports | | Total | |
|---|---|---|---|---|---|---|
| 1981/82 | 11568 | | 207 | - | 11775 | - |
| 1982/83 | 10007 | (13.5) | 335 | 61.8 | 10342 | (12.2) |
| 1983/84 | 9111 | (9) | 2081 | 521.0 | 11192 | 8.2 |
| 1984/85 | 8289 | (9.1) | 2963 | 42.4 | 11252 | 0.5 |
| 1985/86 | 9287 | 12.0 | 1510 | (49.1) | 10797 | (4) |
| 1986/87 | 10283 | 10.7 | 1422 | (5.9) | 11705 | 8.4 |
| 1987/88 | 9957 | (3.2) | 2784 | 95.8 | 12741 | 8.9 |
| 1988/89 | 8618 | (13.5) | 3554 | 27.6 | 12172 | (4.5) |
| 1989/90 | 8817 | 2.3 | 2786 | (21.8) | 11603 | (4.7) |
| 1990/91 | 5865 | (33.5) | 1640 | (41.2) | 7505 | (35.3) |
| 1991/92 | 2709 | (64.0) | 1332 | (18.8) | 4041 | (46.2) |
| 1992/93 | 2175 | (19.8) | 451 | (66.2) | 2626 | (35.0) |
| 1993/94 | 3804 | 74.9 | 139 | (69.2) | 3943 | 50.2 |
| 1994/95 | 4631 | 21.7 | 150 | 7.9 | 4781 | 21.3 |
| 1995/96 | 4956 | 7.0 | 48 | (68.0) | 5004 | 4.7 |
| Total | 110,077 | (28.0) | 21,402 | 416.3 | 131479 | (39.7) |
| Average | 7338 | (1.9) | 1427 | 27.8 | 8765 | (2.6) |

Source: Computed from various reports, DDE

It is noted that the Shola Dairy Plant has a nominal capacity of processing 60 tones of liquid milk equivalent per day or 21.9 million liters/annum. Despite such level of capacity, the fresh milk intake (Table 4) constituted between 9.9% (1992/93) and 52.8% (1981/82) of the plant's capacity. The average intake for the whole period (1981/82-1995/96) was 33.5%.

To supplement the local production, milk powder and butter oil were imported and reconstituted and toned with fresh milk at the plant. The imported milk powder raised the capacity utilization on average to 40% (Table 4).

As indicted in Table 4, the annual growth rate of fresh milk intake over a period of 15 years was below zero and was about 1.9%. Similarly, the total intake including powder milk in liquid milk equivalent dropped at a rate of 2.5% over the period under discussion. From these analyses, it can be concluded that the Shola Dairy Plant (DDE) has been operating below its nominal capacity and its future role in liquid milk market is questioned.

To project fresh milk flow through the plant, the average growth rate over the period 1990/91 - 1995/96, which was 3.3% (Table 4) is used. Based on this, fresh milk flow through the Shola plant over the period 1996/97 - 2000/2001 will be as indicated in Table 5.

**Table 5. Projected fresh milk intake of shola plant**

| Year | Fresh milk intake ('000lts) |
|---|---|
| 1995/96 | 4956 |
| 1996/97 | 5120 |
| 1997/98 | 5289 |
| 1998/99 | 5464 |
| 1999/2000 | 5644 |
| 2000/2001 | 5830 |

**Source: Projected from Table 4**

#### 4.1.1.2 Supply through traditional marketing sub-system

The bulk (82%) of fresh milk sold in Addis Ababa is channeled through the traditional marketing subsystem. The participants in this subsystem are intra and peri-urban milk producers. Different studies have attempted to indicate milk outlets for peri-urban and intra-urban producers and the volume supplied to the city. According to ILRI's survey (1992), 69% of the fresh milk marketed by intra-urban producers and 96% of that produced by peri-urban producers are sold to government and private catering institutions. None of the intra-urban producers sell

fresh milk to DDE. The small scale producers in the city almost exclusively sell directly to consumers, who pay relatively higher prices for fresh milk.

Because of lack of time series data, it is too difficult to indicate milk supply trends and further scope for development of this sub-system. However, to indicate the potential milk flow through the system over the period 1996/97-2000/2001, projection has been made based on the 1995/96 figures (Annex 1) and using the growth rate of 3.3% which has been derived from milk intake growth of the Shola Plant. Hence, as indicated in Table 6 the milk supplied to the city is expected to increase to 22.75 million liters by the year 2000/2001.

### 4.1.2 Import

Imported dairy products have a substantial market share in the Addis Ababa dairy products market. Imported milk powder of 11213 lt./day in liquid milk equivalent has a market share of 23% (DDE, 1994). It has also been noted that some supermarkets import fresh milk and sell to high income groups.

**Table 6. Milk supply projections of the traditional marketing sub-system**

| Year | Supply ('000) |
|---|---|
| 1995/96 | 19340 |
| 1996/97 | 19978 |
| 1997/98 | 20,637 |
| 1998/99 | 21,318 |
| 1999/2000 | 22,021 |
| 2000/2001 | 22,748 |

## 4.2 Demand for liquid milk

The demand for fresh milk in Addis Ababa exceeds supply, except during the long fasting period (March-April) when the demand for dairy products drops. Between the years 1991-94 the excess demand for milk in Addis Ababa was on average 15.5 million liters/annum (DDE, 1994). The same study indicated a per captia consumption of 207 lit/household per annum.

The demand for a commodity depends upon consumer tastes and preferences, population size, price of the product and prices of substitutes and consumers' income. Other things remaining constant, demand for fresh milk has been projected based on population growth of 5.5%, family size of 5 persons per household, per capita consumption level of 207 lt./household/annum and milk

consuming households of 40%. Based on these parameters, the projected demand for milk is given in Table 7.

**Table 7. Projected demand for fresh milk, '000 lt.**

| Year | Population (Million) | Household (Million) | Consuming household (Million) | Consumption Million Lt. |
|---|---|---|---|---|
| 1996 | 2.10 | 0.42 | 0.17 | 35.19 |
| 1997 | 2.22 | 0.44 | 0.18 | 37.26 |
| 1998 | 2.34 | 0.47 | 0.19 | 39.33 |
| 1999 | 2.47 | 0.49 | 0.20 | 41.40 |
| 2000 | 2.61 | 0.52 | 0.21 | 43.47 |
| 2001 | 2.75 | 0.55 | 0.22 | 45.54 |

## 4.3 Demand and supply gap

The population of Addis Ababa is expected to reach 2.75 million people by year the 2001 (Table 7). Correspondingly, the projected demand for fresh milk in the same year will be 45.54 million lt. The supply volume will be about 31.4 (Table 8) million lts which will be short of demand by 31%.

In the short run (1997-2001), the liquid market in the capital will remain unsatisfied with a supply shortfall of 25-31% (Table 8). Thus, there will be a scope for development of dairy farms in the peri-urban areas as the market is variedly available.

**Table 8. Comparisons of projected demand and supply of fresh milk (Million lts).**

| Year | Demand | Supply* | Gap |
|---|---|---|---|
| 1995/96 | 35.19 | 27.19 | 8.00 |
| 1996/97 | 37.26 | 27.99 | 9.27 |
| 1997/98 | 39.33 | 28.83 | 10.50 |
| 1998/99 | 41.40 | 29.68 | 11.72 |
| 1999/2000 | 43.47 | 30.57 | 12.90 |
| 2000/2001 | 45.54 | 31.48 | 14.14 |

Note: Import has been assumed at 2.9 million lts of liquid milk equivalent/annum

* is a summation of Tables 5 and 6.

## 5. Findings and recommendations

### 5.1 Findings

- Both in the peri- and intra-urban areas, the bulk of milk produced 59% and 74%, respectively are sold to the market in fresh form.
- Liquid milk outlets include immediate users, catering institutions, the Shola Plant (DDE) and retailers. The major outlets for intra-urban producers are direct (immediate consumers), while for those in the peri-urban area is the Shola Plant (DDE).
- Proximity, prices, lack of alternative options and a combination of these factors affect selection of one or the other sales outlets.
- The dairy market in Addis Ababa has not yet been saturated. The existing and projected supply does not satisfy the prevailing and potential demand for milk. The supply shortfall range between 9.3-14.14 million lts/annum between the year's 1996/97-2000/2001.
- Milk intake of the Shola Plant over a period of 15 years (19981/82-95/96) showed in most cases a declining trend, which resulted in an average growth rate of 1.9%.

### 5.2 Recommendations

- To narrow down the gap between demand and supply, infrastructures including roads, collection points and chilling centers need to be built in the countryside so that additional milk could flow from the milk shed to the city. Private investment in the dairy sub-sector is also believed to play substantial role in minimizing the gap.
- The Shola Dairy Plant has chronically been under-utilized. Over a period of 15 years (1981/82-1995/96), the milk intake of the plant grew at a rate of 1.9% per annum. If the plant is to run at optimum capacity, some measures need to be undertaken. Either the plant may have to be sold out to the private sector or dairy co-operatives/commercial need to have shares in the ownership.
- To enhance the role of organized marketing sub-sector will play, it is important to encourage the formation of dairy associations or co-operatives that could organize milk collection, processing and distribution.

**Annex 1 Number of milking cows, milk output and marketed amount (Lts).**

| Location | Milking Cows | Milk Production (lts) | Marketable Fresh Milk (lts.) |
|---|---|---|---|
| 1. Intra-urban (Addis Ababa) | | | |
| - Central (woredas 1-7,14,15,20) | 1,577 | 2,610,566 | 1,931,819 |
| - North (9 & 10) | 731 | 1,210,097 | 895,472 |
| - North West (8) | 485 | 802,869 | 594,123 |
| - North East (11-13,16,17) | 3,806 | 6,300,452 | 4,662,334 |
| South (18,19,21) | 2,409 | 3,987,859 | 2,951,016 |
| - South West (22-25) | 2,997 | 4,961,234 | 3,671,313 |
| S. Total | 12,005 | 19,873,077 | 14,706,077 |
| 2. Peri-urban | | | |
| Kaliti and Akaki | 1934 | 3,201,543 | 2,369,142 |
| - Kotebe | 673 | 1,114,084 | 824,422 |
| - Sendafa | 79 | 130,777 | 96,775 |
| - Sululta | 508 | 840,943 | 622,298 |
| - Sebata | 589 | 975,031 | 721,523 |
| S. Total | 3,783 | 6,262,378 | 4,634,160 |
| Total | 15,788 | 26,135,455 | 19,340,230 |

**Sources: Unpublished data from Milk Producers' Association and Region 14 Agricultural Bureau 1995**

**Note: Lactation Length = 267 days and milk yield = 6.2 lts/cow/day (DDE, 1994)**

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# Small Ruminant Production in Ethiopia: Prospects for Improving Productivity

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**Abstract**

Sheep and goats are a major source of income (cash) and food protein for rural farmers in most parts of the tropics. In spite of the numerical importance of small ruminants in Ethiopia, their productivity is still low due to poor management, diseases and inadequate nutrition. Direct and indirect losses occur through mortalities, reduced weight gain, poor reproductive performance and condemnation of diseased organs at the abattoir. This paper describes the main production systems (pastoral, mixed farming and smallholder farming systems) and the major constraints to small ruminant production in Ethiopia. It is suggested that effective control strategies of infectious diseases e.g. Peste des Petits Ruminants (PPR), Contagious Caprine Pleuro-Pneumonia (CCPP), Respiratory diseases and Parasitic diseases e.g. liver flukes and nematode infections, which are endemic and of paramount economic importance, could significantly contribute to the overall improvement of small ruminant productivity. An integrated approach towards sustainable disease control using a combination of chemotherapy, resistant indigenous breeds, improved nutrition, vaccination and environmental management based on the knowledge of the biology of the causative organisms and a sound understanding of the epidemiology of diseases in Ethiopia is discussed. Examples of such combination of the use of epidemiological information, pasture management and low cost supplements with medicated-molasse-urea blocks to control endoparasites in the highland sheep of Ethiopia are reported.

## 1. Introduction

Small ruminants are widely distributed and are of great importance as major sources of livelihood for the small-holder farmers and the landless in rural communities in developing countries. Approximately one half of the sheep and three quarters of the goat population in developing countries inhabit the tropics (Coop, 1985), where the two species form an important component of traditional small farming system. In Ethiopia, small ruminants constitute a major portion (estimated at 24 million sheep and 18 million goats) of the livestock resources. In spite of their numerical importance, their productivity is still low due to poor management, poor reproductive performance, diseases and inadequate nutrition. The recurrent loss in productivity and profit is often due to parasitic infections among which helminth infections are a common problem (Gall, 1981). Profitability from sheep farming is also limited by low performance in terms of market weight, overall reproductive efficiency, wool yield and high mortality (Mukasa-Mugerwa and Lahlou-Kassi, 1995).

In Ethiopia, sheep and goats represent an important component of the farming system providing about 12% of the value of livestock products consumed at the farm level and 48% of the cash income generated, but accounting for only 6.6% of the capital invested in the livestock sector by farmers (Kassahun *et al.*, 1989). They provide 46% of the value of national meat production and 58% of the value of hide and skin production and play an integral part of the production systems (i.e. mixed farming system, extensive production system) in which they serve various functions.

## 2. Small ruminant production systems

### 2.1 *Mixed crop/livestock farming system (small-holders)*

In the central highlands of Ethiopia where 75% of the sheep and about 28% of the goat populations are found, small ruminants depend mostly on grazing fallow lands and crop residues usually with no extra-supplement and receive minimum health care. Farmers maintain one to three rams (depending on the size of the flocks) for year round breeding. Cattle are commonly kept alongside for draft, meat, milk and manure production essential for cropping.

### 2.2 *Pastoral system (nomadism, semi-nomadism or transhumance)*

In the lowlands of Ethiopia, livestock is comprised of large flocks and herds of sheep and goats, cattle and camels mainly transhumants, where only surplus are sold at local markets or trekked to major consumption centres.

## 3. Major constraints to small ruminant production

### 3.1 *Parasitic diseases*

Several species of nematodes have been reported in Ethiopian sheep and goats in Ethiopia. Those of economic importance include Haemonchus contortus, Trichostrongylus colubriformis, Longistrongylus elongata, Dictyocaulus filaria. Although the same helminth parasite species are found to infect both sheep and goats, sheep are likely to carry heavier worm burdens. This is mainly due to differences between the two species in grazing habits. Sheep graze at the root of the grasses which offers an adequate micro-climate for the development and survival of free-living larvae, while goats prefer to browse threes and shrubs if given the opportunity.

Studies on the epidemiology of nematode parasites of sheep in the highlands of Ethiopia (Tembely *et al.*, 1997, in press) have shown a marked seasonal variation in nematode parasite population dynamics throughout the year. Active development occurs during most of the rainy season and grazing animals harbour a variable, but significant, number of advanced fourth stage larvae and immature adult worms. By the end of the rainy season, the majority of $L_3$ acquired undergo arrested development within the host animals and faecal egg counts decline and remain consistently low during the dry season but sharply increase with the onset of the rainy season when

pasture larval challenge and intake of infective larvae increases.

The phenomenon of periparturient rise in faecal egg output is of great importance in the epidemiology of gastrointestinal nematodes of sheep and has been extensively reported under tropical conditions (van Geldorp and Schillhorn, 1976; Agyei et al., 1991). A study on the periparturient rise (PPR) in nematode egg counts in Menz and Horro ewes in the highlands of Ethiopia showed an increase in FEC in pregnant/lactating ewes as early as two weeks before lambing and persisted up to eight weeks post-partum when lambing took place at the end of the wet season (Tembely *et al.*, 1995). Thus, pregnant/lactating ewes are the major source of infection for new born lambs.

A major disease constraint to sheep production in the Ethiopian highlands is fasciolosis. In sub-Sahara Africa, incidence of bovine fasciolosis has been reported to reach as high as 60% and up to 50% liver condemnation rates and 50% reduction in live weight (Hyera, 1984). Njau *et al.* (1988) reported a loss of 72% of the flock at ILCA's Debre Berhan Station in 1985 with an infection rate of 83%. Both Fasciola gigantica and F. hepatica are present, the former having a wider distribution. The snail host remains confined to drainage channels, seepage sites, the edges of permanent ponds, rivers and lakes for most of the year. The population of the aquatic species shows big fluctuations during the year. During the rainy season there is a rapid decline in snail numbers. At the end of the rainy season the snail population begins to increase. Herbage infestation by metacercaria remains high for most of the dry season and gives rise to acute disease if sheep are left untreated. Metacercaria may survive for three months in relatively hot and dry location (Njau and Scholtens, 1991), and up to 10 months in the wet tropics (Oven, 1989). Aestivation during the dry season is the survival mechanisms of the snail intermediate host and contamination of the pasture is limited to the wet period. High to low prevalence rates of infection are reported among sheep depending on the management practices (tethering) and high mortalities are often associated with concurrent infection from black disease, the combined result of Fasciola/Clostridium novyi infections.

### 3.2 *Infectious diseases*

#### 3.2.1 *Peste des Petits Ruminants(PPR)*

PPR is primarily a disease of goats and sheep and spreads within and between these species by contact. Cattle may be infected by contact with sick goats (Dardiri *et al.*, 1976) but also act as "dead end-hosts" (Gibbs et al., 1979). The possible role of game animals in the epidemiology of PPR is undocumented, as is that of camels. Morbidity and mortality may be extremely high in closely confined animals. It appears that PPR is widely distributed throughout sub-Saharan Africa and has been reported in Ethiopia (Abraham *et al.*, 1991; Roeder et al., 1994) where outbreaks among goats in the southern part of the country resulted in high mortality rate (70%). The occurrence of the disease in Ethiopia was closely linked to the introduction of new stock. The disease is reported to be spreading rapidly during the past ten years. This is probably caused so much by nomadic pastoralism and increased movement of small ruminants associated with exportation from the horn of Africa to the Arabian peninsula.

3.2.2 *Contagious Caprine Pleuro-Pneumonia (CCPP)*

CCPP is a cause of major economic losses to goat production in Africa and Asia (Rurangirwa and McGuire, 1996) but sheep and deer can also be infected artificially. The incidence of the disease in Ethiopia was reported by Mebratu (1988). Since the etiology was doubtful until the importance of mycoplasma F-38 was recognized, the epizootiology of CCPP is not well defined. The natural infection occurs aerogenically by direct contact.

3.2.3 *Respiratory disease syndromes*

In the highlands of Ethiopia, respiratory diseases with multi-factorial etiology are common and constitute one of the major causes of mortality in sheep. Among the causal agents, Pasteurella spp, Mycoplasma marginini, maedi-visna viruses have been confirmed (Roger *et al.*, unpublished data) along with the sheep lungworm, Dictyocaulus filaria.

3.3 *Nutritional constraints*

The low efficiency of available feed utilization (forages, crop residues, agro-industrial by-products) and the inadequate supplies (seasonal fluctuations in quantity and quality) of feeds during most part the year, severely influence the reproductive efficiency and disease status of small ruminants in Ethiopia.

3.4 *Reproductive wastage*

A number of studies carried out in the highlands of Ethiopia have shown that reproductive wastage due to infertility, embryonic mortality, prenatal loss and morbidity impose a serious limitation on small ruminant production (Wilson, 1989; Mukasa-Mugerwa *et al.*, 1994; Mukasa-Mugerwa and Lahlou-Kassi, 1995).

## 4. Strategies for improving small ruminant productivity

4.1 *Disease control*

4.1.1 *Use of effective broad-spectrum drugs with sustained anthelmintic activities*

Successful control of helminth infections in livestock in developing countries would heavily depend upon the availability and proper utilization of effective anthelmintic. Although the risk of anthelmintic resistance is believed to be low in Ethiopia, there are increasing reports of its occurrence from neighbouring countries (Bjorn et al., 1991; Mwamachi et al., 1995). The lack of epidemiological data and anthelmintic drugs for controlling endoparasites is a major handicap to the improvement of small ruminant production in Ethiopia. Salvage treatment is of common practice and treated animals return to the communal contaminated grazing lands, therefore, limiting the

effectiveness of the use of anthelmintic.

4.1.2 *Assessment and monitoring of anthelmintic resistance*

Anthelmintic resistance in nematode parasites of sheep and goats occurs with all the broad and moderate spectrum anthelmintic (Prichard, 1990). For optimum economic benefit from the use of anthelmintic it is essential to assess and monitor the state of the development of anthelmintic resistance. Using an annual anthelmintic rotation programme based on knowledge of the parasite species involved, a better understanding of the local epidemiology and cost-effectiveness of anthelmintic treatment will contribute in reducing the development and spread of anthelmintic-resistant nematodes. Currently very little is known about the status of anthelmintic resistance in Ethiopia.

4.1.3 *Grazing management*

The short survival period of nematode pre-parasitic stages in most of the tropics provide an excellent means of controlling nematode infection through rotational grazing. For example, a study conducted at ILRI Debre Berhan station (Tembely and Diedhiou, unpublished data) to determine the annual patterns of development and survival of sheep nematode infective larvae on pasture, has shown that longevity of infective larvae varied between two to six months when eggs were deposited between June and October. During the dry season and the short rainy season (between November and June) eggs failed to develop into infective stages. This suggests that the short period (4 to 5 months) for the acquisition of trichostrongylid infective larvae from pasture can be efficiently exploited in a strategic treatment programme to interrupt the transmission cycle of sheep nematode parasites possibly in combination with a rotational scheme. However, due to the heavy pressure on the land and communal grazing, successful implementation of such rotation schemes would require collaboration of scientists, farmers and decision/policy makers.

4.1.4 *Uses of Vaccines*

A saponin killed CCPP vaccine developed by Rurangirwa *et al.* (1987) has shown to confer protective immunity to this disease over 12 months. Irradiated lungworm larvae (Getachew *et al.*, 1987) have also proven to be effective against Dictyocaulus filaria infection in sheep. With regard to PPR, the rinderpest tissue culture vaccine produced by the National Veterinary Institute (NVI) at Debre Zeit provides a good protection.

4.1.5 *Breeding for disease resistance*

It is now established that indigenous breeds in the tropics have developed a range of unique adaptive traits which enable them to survive and be productive under different environmental stresses. Evidence acquired in the last 40 years has shown clearly that a significant proportion of intraspecific variation in the resistance to sheep to gastrointestinal nematodes is genetically determined (Gruner and Cabaret, 1988; Gray,

1991; Baker, 1995; Roberts *et al.*, 1995). There are some good examples among small ruminants where resistant breeds for resistance to nematode infections have been identified. This includes the Red Maasai of East Africa (Baker, 1995).

Identification and exploitation of resistant breeds/individuals is of economic interest in areas where severe production losses occur as a result of helminth infections. The major benefit from selecting for host resistance to gastrointestinal trematodes is reduction of pasture contamination and less reliance on frequent anthelmintic treatment. Thus, genetic selection for host resistance remains one of the few options that has a low cost and requires minimal input by farmers. Gebrekiros (1990) compared breeds of indigenous Ethiopian sheep for their resistance to endoparasites and found the Arsi more resistant than the Adal, the Horro and the Blackhead Somali. Currently the Menz and the Horro highland sheep are being evaluated at the ILRI Debre Berhan Research Station for between- and within-breed genetic variation for resistance to internal parasites. This study has shown a lack of significant breed difference in faecal egg counts between the Horro and the Menz sheep, while there was a clear indication of within-breed variation in lambs at a young age (2 to 3 months of age), providing an opportunity for within-breed improvement through selection based on either packed cell volume (PCV) or faecal egg counts (FEC) .

### 4.2 *Improved nutrition*

Several studies have demonstrated that the development of acquired immunity to gastrointestinal nematode infections was enhanced in grazing animals which received an additional supplementation with protein-rich concentrate (for example urea and cottonseed cake). However, supplementation of grazing sheep with protein is expensive and may, therefore, have a limited application in developing countries. Recent research at ILRI Debre Berhan research station indicates that it is feasible to feed low-cost nitrogen and energy supplements with a low quality roughage diet to enhance the ability of pen-fed sheep to resist infection with gastrointestinal nematodes. In situations where nutritional deficiencies are likely to exacerbate the detrimental effects of parasitic infections, the use of low cost supplements such as molasses-urea blocks (MUB) have enhanced the animal's ability to utilize the available diet and assist the animal to withstand the infection challenge (Knox and Steel, 1995; Shaw *et al.*, 1995). Substitution of medicated-MUB (M-MUB) for MUB can then occur for short periods during the times when parasite challenge is high or during the periods of low host immunocompetence caused by physiological stresses related to reproduction. It is essential, when designing improved feeding strategies in limited-resource situations, to develop technologies that are acceptable to local producers and which take account their unique motivation for raising small ruminants.

### 4.3 *Improved reproductive performance*

Studies carried out in the highlands of Ethiopia (Mukasa-Mugerwa and Lahlou Kassi, 1995) suggest that reproductive performance could be optimized by improving feeding regimes of breeding ewes through a better utilization of on-farm crop by-product or

leguminous multipurpose trees, setting up rural small-scale fattening schemes to absorb culled females and surplus males where market prices can reward for good quality meat. Efforts should be made to control non-disease factors to minimize lamb mortality and susceptibility to infectious diseases.

Fertility studies in livestock have generally focused on the female side with much less emphasis on the male side. Further studies carried out at ILRI Debre berhan on reproductive characteristics of Ethiopian highland sheep (Toe *et al.*, unpublished data) support the use of testicular measurements to improve flock fertility.

## 5. Conclusion

Controlling helminth infections in small ruminants offers an opportunity to increase their productivity in Ethiopia. An integrated approach will contribute to increased live weight, reduced mortality and reduced labour costs. Disease control measures should combine strategic anthelmintic treatments based on sound epidemiological data with other means of control such as exploitation of resistant breeds, pasture management, improved nutrition and use of available vaccines. Efforts should be oriented towards a sustainable control strategies as this constitutes an integrated part of the overall improvement of agricultural production on the basis of an ecologically sound approach. It is essential to involve farmers in the development and adoption of any available technology package for disease control to be successful. Many farmers are aware of the economic benefit of the use of veterinary medicines, but often times lack financial resources. Therefore, there is a need for a redefinition of the role of the public sector in the provision of veterinary services. A prompt and adequate dissemination of research results and the active participation of farmers in the development of environmentally acceptable production systems are some challenges the animal health sector is facing today.

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# ANIMAL PRODUCTION

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# Relationship Between Growth Performance and Subsequent Productivity in Horro Sheep

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## Abstract

A total of 1399 lambing records of Horro ewes collected over a 15 year period (1978-1993) were analyzed to estimate the relationship between ewe growth performance, as measured by weaning (WWT), six month (SWT) and yearling weights (YWT), and subsequent productivity at adulthood as measured by number of lambs born (NLB), and numbers of lambs weaned (NLW) per ewe, kg of lamb weaned per ewe (KGWL), kg of lamb weaned per kg body weight (KGKG) and per kg metabolic body weight (kg $^{0.73}$) (KGKGM) of ewe. Simple correlations between the growth performance indicators and measures of productivity were calculated. WWT had no significant relationship ($p>0.05$) with any of the productivity parameters, while SMW had highly a significant relationship with NLB ($p<0.01$), but not with the other parameters. YWT had significant relationships ($p<0.05$) with all productivity estimates except NLB. The results indicated that YWT was significantly related with most productivity parameters and may be used for selection of replacement ewes. But the low coefficients of determination ($R=3.9$-$8\%$) observed in all analysis and the low correlations ($r=0.02$-$0.22$) imply that use of early life growth performance to select individual ewe replacements may not bring much improvement in production performance. Therefore, the use of growth performance should be geared towards management of a group of ewe replacements rather than as a selection criteria for ewe replacements.

## Introduction

Growth differences may have persistent influence on adult reproductive and productive performances. Umberger *et al*. (1985) reported that accelerated growth during rearing resulted in increased lambing rate, but impaired milk production. In a study by Gould and Whiteman (1975) a weak negative relationship was found between ewe's 70-day weight and the estimated amount of milk produced as measured by 70-day weight of lambs. On the other hand, Burfening and Kress (1992) reported positive, but small, correlation between growth traits and subsequent most probable producing ability in sheep.

Most reports on the relationship of growth performance with adult reproduction were strong and positive. In sheep, Reardon and Lambourn (1966), Allden (1979), and Langelands *et al* (1984a) have found that ewes fed at a higher level during rearing show better reproductive performance than ewes fed at lower level. Though persisting body weight difference into adulthood may account for most of the variations in production and reproduction due to differences in growth performance, the work of Williams (1984) indicated that growth of ewes may have its influence by a process which acts in addition to the influence of body weight.

Information on the relationship of growth performance with subsequent production is required as a guide to management and selection of replacement ewe lambs for increased productivity. Such information is lacking for the Horro sheep. This study was undertaken to evaluate, from existing data on sheep, whether growth performance had any relation to subsequent productivity or not.

## Materials and methods

*Location and data*: Data were collected from a flock of Horro sheep (described by Galal, 1983) which was established in 1977 at the Bako Research Centre (09°6'N, 37°09'E, 1650 m a.s.l. and 1200 mm annual rainfall, 28°C and 13°C mean maximum and minimum temperatures). Data collection covered a 15-year period (1978/79 to 1992/93); representing a total of 1399 lambing records.

Productivity traits considered in this study were number of lambs born (NLB) and weaned (NLW) per ewe lambing, kg of lamb weaned per ewe (KGWL), per kg body weight (KGKG), and per kg metabolic weight (kg $^{0.73}$) (KGKGM) of ewe lambing. Growth performance was represented by weaning (WWT), six month (SMW) and yearling weights (YWT). WWT was recorded at 90 $\pm$ 7 days, while SMW and YWT were recorded at 180 $\pm$ 15 days of and 365 $\pm$ 15 days of age, respectively. Lamb weaning weight was adjusted to 90 days by linear extrapolation from birth to weaning.

*Management*: Ewes were kept indoors during mating and were fed Rhodes grass (*Chloris gayana*) hay *ad-libitum* and were supplemented with 333 g/head/day concentrate ration composed of 49% maize, 49% noug (*Guizotia abyssinica*) cake, 1% common salt and 1% bone meal. Ewes were joined in single-sire groups of 10-25 ewes over 42 days starting either in late November or early December. No supplement was given to the ewes during pregnancy and they were allowed to graze on natural pasture. After lambing ewes and lambs were kept indoors for about two weeks during which ewes were given hay *ad libitum* and supplemented at a rate 200 g/head/day with a concentrate ration. In most of the years, the concentrate supplement continued until weaning. Though animals were allowed to breed for the first time starting at about 6-7 months of age, in this analysis only those ewes which were bred after they achieved yearling age were considered. Health management practice comprised vaccination against anthrax, sheep pox, pasteurellosis and CCPP, fortnightly spray against external parasites and prompt treatment of sick animals.

*Statistical analysis*: The data were analyzed by the least squares procedures (Harvey, 1990). In all cases one general fixed model was used. Growth parameters (WWT, SMW, YWT) were included in the model as independent variables along with other environmental variables (year of lambing, ewe type of birth, parity). Individual ewe performances (NLB, NLW, KGWL, KGKG, and KGKGM) were considered as dependent variables. In a preliminary analysis, year of lambing was found to be significant and data were adjusted accordingly using constants derived from the analysis.

In the final analysis, WWT, SMW, and YWT were categorized into three, three and four categories, respectively. Correlations among the different independent

variables (WWT, SMW, YWT) pooled for all lambings were calculated. Also correlation between independent and dependent variables were calculated.

## Results and discussion

*Number of lambs born (NLB) and weaned (NLW)*: Ewe type of birth and parity had significant ($p < 0.05$ and $p < 0.001$, respectively) effect on both NLB and NLW (Table 1). Table 2 shows that twin born ewes had 0.06 and 0.11 more NLB and NLW per ewe than single born ewes. This is in agreement to More (1976) who reported that ewes born as multiples were more productive than singles. However, this result disagrees with Thrift and Dutt (1976) who reported no differences in lambing and weaning rates between single and twin born ewes. NLB varied from 1.20 to 1.44, while NLW varied from 0.62 to 0.97 between first and sixth parities. Similarly, Wright *et al.* (1975) have shown that age of ewe is a significant source of variation for number of lambs born and lambs reared per ewe lambing.

SMW had a highly significant effect on NLB, while YWT had a highly significant effect on NLW. Langelands *et al.* (1984a) and Umberger *et al.* (1985) reported differences in number of lambs born to be due to differences in nutritional management during early life (weaning to 15 months), while Langelands *et al.* (1984b) reported differences in lamb mortality rate to be due to ewe nutritional treatment during early life. The reports corroborate the results of this study. No significant effect of WWT was observed on NLB and NLW. Langelands *et al.* (1984a) reported ewes subjected to low nutrition (high stocking rate) to three months of age have lower fecundity than ewes reared under low stocking rate, when adult stocking rate (after 15 mo. of age) remained high irrespective of stocking rate between 3 and 15 months of age. But, no difference was observed when adult stocking rate was low. Similarly, lack of significant effect in NLB and NLW due to weaning weight differences in this study could be due to the modifying effects of ewe growth after weaning. Coefficient of determination in the model were only about 8% for NLB and 6.2% for NLW. This could be the result of analysis of performance of individual ewes rather than group averages. Least squares means of NLB and NLW for ascending categories of WWT, SMW and YWT are presented in Table 2.

*Productivity in weight (KGWL, KGKG, and KGKGM)*: The type of birth and parity had highly significant effect ($p < 0.001$) on KGWL. More and O'ferrall (1976) reported that ewes born as multiples weaned 2.5 kg more lamb ($p < 0.05$) than single born ewes at 2 year of age, while Aibazov (1975) reported that progeny from 2.5 and 4.5 year old ewes were different in weight starting from birth to 16 months of age. Both reports are in agreement with the results from this study. Table 1 shows YWT had highly a significant ($p < 0.001$) relationship with KGWL ($r = 0.22$), while WWT and SMW did not ($p > 0.05$). Burfening and Kress (1992) reported that correlation between ewe most probable producing ability and her early life growth performance progressively increased when expression of early growth performance was changed from birth to 60 and to 120 days of weight. Similarly, in this study progressive increase in correlation between KGWL and growth performance was observed as growth advanced from weaning at 3 months to six months and to yearling weights. This may account for the lack of significant relationship between KGWL and WWT,

and SMW while there existed significant relationship with YWT.

Since the lambing interval in this study was about one year, KGWL, KGKG and KGKGM values are comparable to productivity indices I, II, III (Wilson and Murayi, 1988), respectively. For Menz sheep Mukasa-Mugerwa *et al.* (1994) reported a value of 6.13, 10.25, 12.20 kg for index I from ewes reared under poor, low and medium planes of nutrition. Values in this study for ascending classes of YWT are 8.8, 9.4, 10.7 and 13.9 (Table 2). Under more accelerated lambing regime, Horro sheep have the ability to produce more than what is reported here due to its high lambing rate and growth potential (Kassahun *et al.*, 1988).

Ewe type of birth and parity and YWT have shown significant influence on both KGKG and KGKGM (Table 1). But the effect of WWT and SMW was not found to be significant. Table 2 shows least squares mean values for KGWL, KGKG, and KGKGM for type of birth, parity and ascending categories of WWT, SMW, and YWT. It appears that increasing YWT resulted in sizeable increase in KGKGM. This implies that growth performance of ewes may have relationship with efficiency of utilization during adulthood.

Table 1. Least squares analysis of variance for variables affecting ewe productivity estimates of number of lambs born (NLB) and weaned (NLW), kg lamb weaned per lambing ewe (KGWL), per kg body weight (GPKG) and metabolic (kg 0.73) weight (GPKGM) of ewe lambing.

| Source | d.f. | NLB | NLW | KGWL | KGKG | KGKGM |
|---|---|---|---|---|---|---|
| Total | 1398 | | | | | |
| Type of birth | 1 | 0.7478$^{*}$ | 2.1693$^{*}$ | 423.58$^{**}$ | 3.9353$^{*}$ | 2.633$^{*}$ |
| Parity | 5 | 1.4974$^{***}$ | 1.1707$^{**}$ | 311.55$^{***}$ | 4.1174$^{**}$ | 2.326$^{***}$ |
| Regression | | | | | | |
| Weaning weight | 1 | 0.6024 | 0.4712 | 43.23 | 0.1902 | 0.155 |
| Six mo. weight | 1 | 3.8377$^{***}$ | 0.2589 | 179.87 | 0.0269 | 0.153 |
| Yearling weight | 1 | 0.3390 | 12.6812$^{***}$ | 1607.89$^{***}$ | 8.2739$^{**}$ | 6.581$^{***}$ |
| Residual | 1389 | 0.1969 | 0.3673 | 61.19 | 0.6454 | 0.403 |
| CV | | 33.9% | 66.3% | 68.4% | 67.4 | 67.2 |
| $R^2$ | | 8.2% | 6.2% | 7.3% | 3.9% | 4.5% |

*** = $p<0.001$ **=$p<0.01$ *=$P<0.05$

Table 2. Least squares means estimates (± SE) of number of lambs born (NLB) and weaned (NLW), kg lamb weaned per lambing ewe (KGWL), per kg body weight (KGKG) and metabolic (kg $^{0.73}$) weight (KGKGM) of ewe lambing.

| Traits* | | N | KLB | NLW | KGWL | KGKG | KGKGM |
|---|---|---|---|---|---|---|---|
| TOTAL | | 1399 | 1.33±.016 | 0.88±.021 | 10.7±.273 | 0.35±.009 | 0.88±.022 |
| TOB | Single | 616 | 1.30±0.13 | 0.82±.018 | 10.0±.375 | 0.33±.012 | 0.83±.030 |
| | Twin | 783 | 1.36±.013 | 0.93±.018 | 11.4±.337 | 0.37±.011 | 0.94±.027 |
| Parity | 1 | 347 | 1.20±.025 | 0.93±.034 | 11.5±.436 | 0.41±.014 | 1.01±0.35 |
| | 2 | 363 | 1.30±.024 | 0.94±.032 | 12.3±.418 | 0.40±.014 | 1.00±.085 |
| | 3 | 288 | 1.35±.027 | 0.97±.036 | 12.1±.468 | 0.38±.015 | 0.96±.038 |
| | 4 | 213 | 1.34±.031 | 0.88±.042 | 10.8±.543 | 0.34±.018 | 0.87±.044 |
| | 5 | 132 | 1.44±.039 | 0.93±.053 | 10.8±.688 | 0.35±.022 | 0.88±.056 |
| | 6 | 56 | 1.33±.060 | 0.62±.081 | 6.9±1.051 | 0.23±.034 | 0.57±.085 |
| WWC | < 11 kg | 320 | 1.31±.032 | 0.91±.044 | 10.8±.563 | 0.36±.018 | 0.90±.046 |
| | 11 - 14 kg | 662 | 1.35±.022 | 0.87±.030 | 10.6±.386 | 0.35±.013 | 0.87±.031 |
| | > 14 kg | 417 | 1.32±.031 | 0.86±.042 | 10.8±.544 | 0.35±.018 | 0.87±.044 |
| SMWC | < 14 kg | 341 | 1.25±.033 | 0.85±.045 | 10.0±.588 | 0.35±.019 | 0.85±.048 |
| | 14 - 17 kg | 624 | 1.31±.023 | 0.89±.032 | 10.9±.412 | 0.36±.013 | 0.90±.033 |
| | > 17 kg | 434 | 1.42±.031 | 0.90±.043 | 11.2±.551 | 0.35±.018 | 0.89±.045 |
| YWC | < 20 kg | 249 | 1.32±0.32 | 0.72±.044 | 8.8±..572 | 0.32±.019 | 0.77±.046 |
| | 20 - 24 kg | 488 | 1.25±.024 | 0.77±.032 | 9.4±.414 | 0.32±.013 | 0.80±.034 |
| | 25 - 28 kg | 384 | 1.31±.026 | 0.88±.036 | 10.7±.465 | 0.35±.015 | 0.87±.038 |
| | > 28 kg | 278 | 1.42±.032 | 1.15±.043 | 13.9±.558 | 0.42±.018 | 1.09±.045 |

* TOB= Type of birth of the ewe WWC= Weaning weight category
SMWC= Six month weight category YWC= Yearling weight category

*Regressions and correlations among traits*: The regression coefficients show that (Table 3) NLB per 100 ewes increases by 3.3 for each kg increase in mean SMW, while NLW, KGWL, KGKG, KGKGM showed increases of 2.6, 29.5, 0.7, and 1.9 per hundred ewes for each kg increase in YWT. Table 4 shows correlation between ewe WWT, SMW and YWT, and with productivity parameters. All the correlation values between the weights were highly significant ($p < 0.01$). Correlations between WWT and SMW, YWT, were 0.85, 0.57, respectively, while the correlation of SMW with YWT was 0.72 for all the 1399 lambings. Kundryukov (1974) found a correlation coefficient of 0.40 between weight at 4½ and 12 month of age in sheep, which is lower than the value found in the present study for both correlation of WWT and SWT with YWT. Kress and Burfeneing (1972) reported the correlation between 180 day weight and yearling weight in heifers to be 0.71, a value which is very similar to

the correlation of SMW with YWT (0.72) in the current study.

The correlation of WWT, SMW and YWT with measures of productivity were in most cases significant ($p<0.05$), but small in magnitude ($r=0.02$-$0.22$). Burfening and Kress (1992) reported similar low correlations between ewe weight at 60 and 120 days with most probable producing ability for 60 and 120 days weight, while Mukasa-Mugerwa *et al.* (1994) reported a higher value ($r=0.46$) than values calculated in this study. However, in the current retrospective work growth was represented by weights at points in time which were further from subsequent lambing times while in the work of Mukassa-Mugerwa *et al.* (1994) it was based on weight gain and the time period extended to subsequent lambing.

Table 3. Least squares mean values of regression coefficients (b) and standard errors (±s.e.) for measures of productivity on growth traits

| | b±s.e | | | | |
|---|---|---|---|---|---|
| Growth trait | NLB | NLW | KGWL | KGKG | KGKGM |
| WWT | -.0138±.0079 | -.0122±.0108 | -.1171±.1393 | -.0025±.0045 | -.0070±.0113 |
| SMW | .0332±.0075* | .0086±.0103 | .2271±.1325 | .0088±.0043 | .0066±.0107 |
| YWT | .0043±.0033 | .0262±.0045* | .2947±.0575* | .0686±.0187* | .0189±.0047* |

* Significant at $p<0.05$

Table 4. Phenotypic correlations of early growth performance parameters within themselves and with measures of productivity parameters

| | SMW | YWT | NLB | NLW | KGWL | KGKG | KGKGM |
|---|---|---|---|---|---|---|---|
| WWT | .85** | .57** | .14** | .08* | .11* | .02 | .04 |
| SMW | | .72** | .22** | .13** | .17** | .05* | .08* |
| YWT | | | .19** | .21** | .22** | .10* | .14** |

* = $p<0.05$ ** = $p<0.01$

WWT=weaning weight; SMW=six month weight; YWT=yearling weight; NLB=number of lambs born; NLW=number of lambs weaned; KGWL=Kilogram weaned per ewe lambing; KGKG= kg weaned per kg ewe weight; KGKGM=Kg weaned per kg metabolic weight of ewe.

## Conclusion

Of all growth performance traits studied, YWT was found to have significant effect on most productivity estimates, except on NLB. With increased YWT of the ewe, increased productivity was observed. Selection of replacement ewes on the basis of their YWT or management of replacement ewes for increased YWT may play important roles in increasing ewe productivity. There exist strong correlations between WWT, SMW and YWT. Thus, WWT and SMW can be used as an early guide towards an optimum YWT. However, the low coefficient of determination in the analysis and low correlation coefficient between productivity estimates and growth performance parameters indicate that much improvement in productivity can not be expected by selecting individual replacement ewes for growth performance. Hence, the information obtained from this study should be used in management of group of ewes towards attaining optimum growth performance.

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# Short Note on Milk Yield, Lactation Curve and Butterfat Content of Horro Ewes at Bako Research Centre

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## Abstract

Milk production of 17 Horro ewes was assessed over a period of 12-weeks. The estimated average lactation yield was 19.2 litres/head and the average daily milk yield was 216 ± 8.8 ml/head. Stage of lactation and parity had significant effects ($p < 0.01$) on milk production. Type of lambing had no significant effect ($p > 0.05$) on milk production. Variation in milk production among ewes was very large with yields ranging from 120 - 370 ml/day and 11 - 33 litres/lactation. The mean butterfat content was 46 g/kg. The sample size used in this study was small, hence more research should be conducted in order to ascertain and establish a reliable lactation curve and butterfat percentage for Horro sheep.

## Introduction

Milk production has direct effect on weight gain of lambs (Njwe and Manjeli, 1992). From 20-60 % of the variation in weaning weights of kids and lambs in the tropics and sub-tropics is accounted for by the variation in the amount of milk produced by the ewe, or the amount sucked by lambs and kids (Peart, 1982. as cit. by Banda, 1994). Kasssahun *et al.* (1989) indicated that lambs are almost entirely dependent on their dams' milk production for their growth, particularly in the first 6 weeks after birth.

The Horro sheep, one of the identified sheep breed for meat production, have a twining rate ranging from 30 to 50 % and a mortality rate of more than 30 % (Kassahun *et al.*, 1989). Even though the Horro sheep have such a desirable economic traits, information on estimates of milk production is meagre and the pattern of the lactation curve is not yet established for this breed. Therefore, due to the fact that milk production during lactation is an important factor affecting mothering ability in sheep, the present preliminary study was undertaken to estimate daily and total milk production during a 12-week period of lactation, to establish lactation curve and to determine butterfat percentage for the Horro sheep.

## Materials and Methods

In 1993, seventeen lactating Horro ewes were used to assess their milk production potential. The ewes were 3 to 8 years of age and were in their 2nd to 8th parities. After parturition, the ewes were group fed and kept indoors until weaning their lambs at 90 days. They were let out for watering twice a day for not more than 10-20 minutes. They were offered Rhodes grass hay *ad libitum* and supplemented with a concentrate ration at a rate of about 300 g/head/day.

The composition of the concentrate ration was 49.5 % ground maize, 49.5 % noug (Guizotia abyssinica) cake and 1% salt. Feed allowance for lambs' consumption was gradually made almost one month after parturition when lambs were able to share feed with their dams.

The initial milk yield for each animal was determined a week after parturition. Thereafter, milk yield was determined every week until the twelve week of the lactation period. On test days, lambs were separated from their dams for about 12 hours (overnight), and early in the morning hand milking was practised, while lambs were at the site of the ewes. The amount of milk obtained during the separation period was multiplied by two to estimate daily milk yield of ewes. Furthermore, milk from a separate group of five ewes which were either in early, mid or late lactation was obtained and combined; and three samples were taken for butterfat percentage determination using the Gerber test. The procedure was repeated for five consecutive days. The data were analyzed by the least squares procedure of Harvey (1990). Milk yield was considered as dependent variable in the model while type of lambing, parity and stage of lactation were considered as independent variables.

## Results and Discussion

The average daily milk yield of Horro ewes during the 12-weeks of lactation is presented in Table 1. The mean total lactation yield for this breed was 19.2 litre/head, while the average daily milk yield was 216 $\pm$ 8.8 ml/head. Variation in milk yield among ewes was large, with yields ranging from 120 to 370 ml/day and from 11.0 to 33.0 litres/lactation. Type of lambing had no significant effect on milk production (Table 2). Stage of lactation and parity had significant effects on milk production ($p < 0.01$). Maximum average milk yield of 315 ml/head/day was attained during the third week of lactation and declined to a minimum level of 100 ml/head/day during the 12$^{th}$ week (Figure 1). The mean butterfat content of Horro sheep during this study was 46 g/kg.

Weekly milk production was estimated using seventeen (17) Horro ewes during the lactation period of 12-weeks in 1993. Maximum weekly milk yield was attained during the third week of lactation after which milk production gradually declined to 100 ml/head/day at the 12$^{th}$ week of lactation. Weaning of Horro lambs at about ninety days of age reported by Solomon (1991) agrees with the considerably decreased milk production of Horro ewes to less than 100 ml/head/ day at about eighty days of lactation. Solomon (1991) indicated that Horro lambs can be weaned at about ninety days if preferential grazing is available for weaned lambs and good condition of ewes is required for high fertility in frequent breeding systems.

The lactation curve for this breed is some what similar to that reported by Coombe *et al.* (1960. as cit. by Njwe and Manjeli, 1992), in that the maximum (peak) weekly milk yield was attained almost during the 3$^{rd}$ week of lactation after which production declined. This implies a more gradual increase of milk production to attain a peak when compared to sheep in Malawi reported by Banda *et al.* (1992) that do so more rapidly in the first week post-partum. The curve also agrees with the lactation curve for Adal sheep reported by Galal and Getachew (1977).

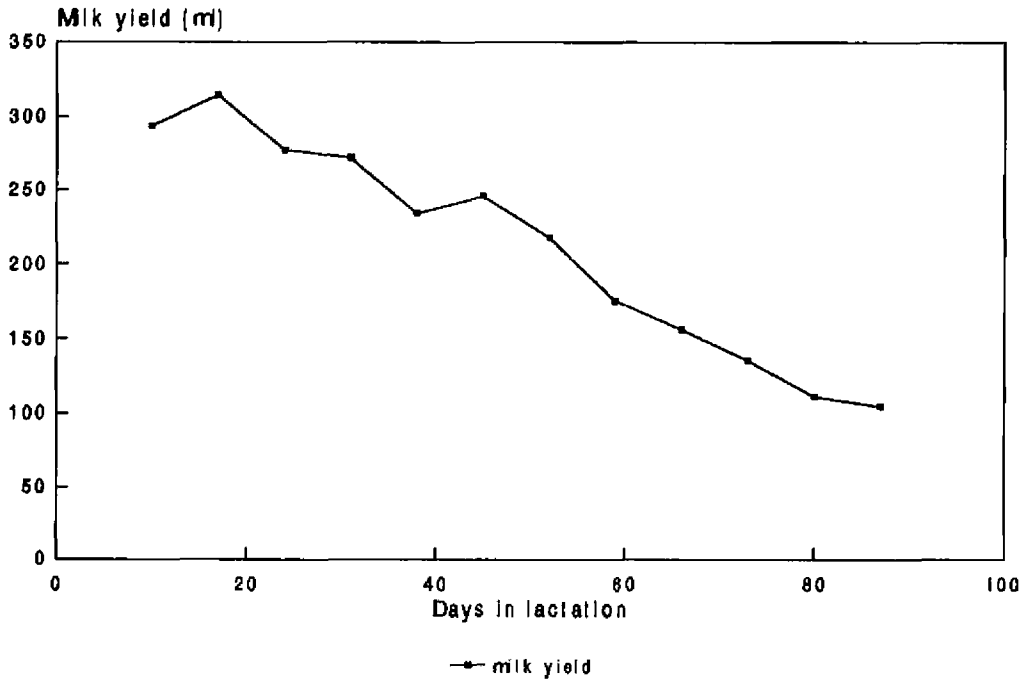


**Figure 1**. Lactation curve of Horro sheep.

The lactation yield of 19.2 litres of milk by the Horro sheep is low as compared to the 23.4 $\pm$.13 litres reported for the Adal sheep (Galal and Getachew, 1977), the 54.5 $\pm$1.3 litres for the Small East African sheep (Banda, 1994), and the 28.0 - 42.0 litres for the Cameroon Dwarf Blackbelly sheep (Njwe and Manjeli, 1992) over a similar lactation period of 12 weeks.

Table 1. Least-squares mean daily milk yield of Horro ewes as affected by type of lambing and parity.

| Variable | N | Milk yield (ml ± s.e.) |
|---|---|---|
| Total | 17 | 216.4 ± 8.8 |
| Type of Lambing | | ns |
| Single | 12 | 205.2 ±10.4 |
| Twin | 5 | 227.0 ±15.2 |
| Parity | | ** |
| 2&3 | 6 | 198.8 ± 14.9 |
| 4 | 3 | 183.6 ± 19.4 |
| 5 | 4 | 218.4 ± 17.2 |
| ≥6 | 4 | 264.8 ± 17.2 |
| Regression Stage of lactation | | b=-19.9 ± 2.3 |

ns=non significant ** $p < 0.01$

The total milk production was also related to the stage of lactation and parity. Parity has been reported to affect milk production in sheep (Banda *et al.*, 1992). Even though, type of lambing had no significant effect on milk production ($p > 0.05$), there was a tendency for twin lambing ewes to produce more milk yield than single lambing ewes (227 vs 205 ml milk/head/day).

Table 2. Mean squares for analysis of variance for milk yield of Horro ewes as affected by type of lambing, parity, and stage of lactation.

| Source of Variation | D.F. | Mean squares |
|---|---|---|
| Total | 204 | 18172 |
| Type of lambing | 1 | 18172 |
| parity | 3 | 56708** |
| Stage of Lactation | 1 | 963381** |
| Reminder | 198 | 13139 |
| Cv | 54% | |
| $R^2$ | 31% | |

**$P < 0.01$

A preliminary observation was also conducted to determine the butterfat

percentage of Horro sheep during this study period. The mean butterfat percentage was 46 g/kg, which is low as compared to the 60 g/kg reported by Banda *et al.* (1992).

Generally, due to the fact that the small sample size used during this preliminary study there is a need to conduct further study in order to ascertain results obtained and to establish a reliable lactation curve and butterfat percentage for Horro sheep.

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# Growth Performance and Concentrate Intake of Horro Calves Reared under Restricted Whole Milk Feeding

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## Abstract

Growth performance and concentrate intake of Horro calves of both sexes reared under different levels of whole milk, starting from the 30th day of age till three months, was studied at the Bako Research Centre. Calves on treatment one, two and three were fed 0 (100% restriction), 73 (50% restriction) and 146 (no restriction) liters of whole milk, respectively and a measured amount of concentrate starting from the 30th day of age. They were weaned at the age of three months. The result showed that three month (weaning) weight was significantly affected by treatment ($p<0.01$) and 30th day (initial) weight ($p<0.01$) of the calves. However, preweaning daily gain was affected ($p<0.01$) by treatment only. The mean three month weight(kg) and preweaning gain(g/h/day) of calves in treatment one, two and three were 36.9, 41.5, 46.9; and 99.1, 170.6 and 248.1, respectively. Both traits showed linear relationship with treatment, i.e with increase in the amount of milk offered. Three month weight increased at a rate of 0.76kg for a unit increase in initial weight. Treatment had no significant effect on total concentrate intake, however, initial weight had a significant effect ($P<0.01$). The mean total intake during the experimental period was 27.9 kg. Concentrate intake increased at a rate of 1.8 kg for a unit increase in initial weight of the calf. From this study it was found that restricting the calf from whole milk was possible starting from 30th day of age but this had an effect on three month weight and preweaning daily gain. Besides, the existing feeding level for calves is sub optimal and warrants further study of the higher levels of feeding whole milk to exploit the growth potential of the calves during the preweaning stage

## Introduction

Restricting milk feeding initiates the calf to start nibbling dry feeds and green forages during the second week of life (Ranjhan, 1977). Introducing roughage and concentrate in the diet at early age will help in early establishment of microbial population and development of the rumen (Ranjhan, 1977). When the rumen becomes functional, the efficiency of milk utilization decreases due to degradation of high quality milk proteins.

In western Ethiopia, farmers keep indigenous animals mainly as a source of draught power. These animals are poor producers of milk. Moreover, their teats are partially functioning, which results in restricted suckling (Legesse *et al.*, 1987; Tesfaye, 1991;). A diagnostic survey made in western Ethiopia indicated that farmers allow newly born calves to have free access to the milk of their dams for some time following calving and milking starts 20-30 days after parturition.

Once milking has started, the calves' access to their dam will be restricted to few minutes before and after the morning and the evening milkings in some cases two teats are milked and the other two are left for calves (Legesse *et al.*, 1987; Kassahun *et al.*, 1988). Therefore, this experiment was designed to compare the growth performance of calves reared under different whole milk restrictions and determine its effect on concentrate intake.

## Materials and methods

Thirty Horro calves of both sexes were randomly assigned to three treatments at the age of 30 days. The treatments were no milk or 100% restricted (treatment one), 50% restricted (treatment two) and no restriction (treatment three) of the amount currently offered at the Centre. Restricted feeding started from the age of 30 days and the total amount of milk offered for calves in treatments one, two and three was 0, 73 and 146 litres of whole milk, respectively. The experimental period was from 30$^{th}$ day to three months of age, and lasted for a period of 68 days. The treatments were formulated based on the Centre's milk feeding system, which is feeding concentrate and 237 litres of whole milk for three months. Before the start of the experiment, all calves were similarly managed. They were fed concentrate and whole milk (91 liters). All calves had free access to water, hay and a measured amount of concentrate daily. The concentrate mixture included maize (49%), noug cake (49%), salt (1%) and bone and blood meal (1%), and provided about 12.7 MJ per kilogram metabolizable energy and a crude protein of about 20.9%. Hay was offered daily but the amount consumed was negligible and was not recorded.

The data were analyzed using the least squares procedure (Harvey, 1990). Treatment, calf sex, treatment by sex, and calf's 30$^{th}$ day weight (initial weight) were included in the model.

## Results

### *Growth performance*

Three month weight of the calves was affected ($p<0.01$) by treatment and initial weight. The mean three month weight of the calves in treatment one, two and three were $36.9\pm1.11$, $41.8\pm1.03$ and $46.9\pm 1.02$ kg, respectively, and had linear relationship with treatment and initial weight. It showed an increase of $0.76\pm0.18$ kg for a unit increase in initial weight. The effect of calf sex, and its interaction with treatment were not significant.

Pre weaning (30$^{th}$ day to three month) daily gain was affected ($p<0.01$) by treatment only. The relationship of treatment with pre weaning daily gain was linear.

### *Concentrate intake*

Concentrate intake was not affected by treatment, calf sex or their interaction. However, initial weight affected ($P<0.05$) total concentrate intake. The overall mean concentrate consumed was 27.9 kg per head. The corresponding values for treatment one, two and three were $28.4\pm4.6$, $26.9\pm4.4$ and $28.6\pm4.2$kg, respectively. Total

concentrate consumed was 27.9 kg per head. The corresponding values for treatment one, two and three were 28.4±4.6, 26.9±4.4 and 28.6±4.2kg, respectively. Total concentrate intake increased by 1.8 kg for one kg increase in initial weight.

Table 1. Least squares mean(±SE) for body weight(kg) at three months of age and preweaning daily gain of calves reared under restricted whole milk feeding

| Source | No | Three month weight(kg) | Preweaning gain g/day/animal) |
|---|---|---|---|
| over all | 29 | 41.9 ± 0.61 | 172.6 ± 8.74 |
| Treatment | | ** | ** |
| T1 | 9 | 36.9 ± 1.11[a] | 99.1 ± 16.06[a] |
| T2 | 10 | 41.8 ± 1.03[b] | 170.6 ± 14.95[b] |
| T3 | 10 | 46.9 ± 1.02[c] | 248.1 ± 14.86[c] |
| Calf sex | | ns | ns |
| male | 14 | 40.9 ± 0.83 | 157.5 ± 12.12 |
| female | 15 | 42.9 ± 0.87 | 187.7 ± 12.61 |
| Regression coefficient(b) | | | |
| 30th day weight | | 0.76 ± 0.19** | -3.76 ± 2.71 |
| mean | | 42.1 | 175.6 |
| standard deviation | | 3.2 | 46.9 |
| CV | | 7.7 | 26.7 |
| $R^2$ (%) | | 72.4 | 74.6 |
| R | | 0.85 | 0.86 |

** = P<0.01; * = P<0.05; ns = not significant

## Discussion

Three month weight of calves raised on different levels of whole milk and *ad libitum* concentrate feeding indicated a linear relationship with increasing level of whole milk offered. The weights obtained in this study were lower than reported by Kebede and Galal (1982) for Horro calves raised under two agro-ecological zones (Bako and Holleta). This could be due to differences in management levels i.e. feeding and environment. Calves from Holleta were heavier than calves from Bako. The linear trend show that the level of milk offered could not support higher level of body weight gain. Calves reared under no milk but concentrate (treatment one) feed showed inferior performance compared with calves raised under whole milk of different levels. Similar result was reported by Roy (1980). Calves reared on too low nutrition

under skim milk for another 30 days showed lower dry matter intake compared with calves raised under whole milk for 90 and 60 days. Roy (1980) indicated that for a calf weaned at five weeks of age, a concentrate mixture containing 16% crude protein (air dry basis), even when restricted to a level of 2 Kg per day, will supply the need of the calf. However, the daily intake of the calves in our experiment was far below this level.

The choice whether to restrict feeding or not, or early wean calves should depend on the objective of production. In areas where partial suckling is followed, a suckling not only benefits the calf but also encourages milk let down, hence, early weaning is not recommended. In pastoral and agro-pastoral systems, calves often get only half of their dams milk. Less milk for the calf means the calf will be lighter at weaning than a calf that gets all its dams milk. The calf will also reach puberty later, and hence reducing its lifetime productivity (Coppock, 1989).

## Conclusion and recommendation

The choice of weaning age or restricted feeding should be based on the objective of production and economics of calf rearing. Besides, from the linear relationship observed, it can be concluded that the feeding practice followed at the Centre is sub-optimal. Hence, higher levels of feeding have to be evaluated as to their effect on calf growth and their economic feasibility.

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# Late Pregnancy Ewe Feeding and Its Effect on Lamb Growth and Survival to Weaning and Body Weight Changes of Ewes in Horro Sheep

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## Abstract

The influence of level of late pregnancy ewe feeding on growth and survival to weaning in Horro sheep was studied from 1994-1996 at the Bako Research Centre. Four levels (0, 140, 210, and 280 g/head/day) of concentrate consisting of maize and noug-cake was supplemented to ewes starting six weeks before lambing. Ewes supplemented with 280 g/h/day (high) of concentrate mixture produced significantly heavier ($P < 0.001$) lambs ($2.9 \pm 0.05$ kg) compared to the non supplemented group ($2.2 \pm 0.05$ kg). Maternal nutritional status on weaning weight (WWT) was not significant ($p < 0.05$). However, there was an increasing trend with increasing feeding level of ewes. Daily growth rate of lambs was influenced by type of birth. Better survival rate (71%) was obtained in the high ewe feeding level, but the difference was not significant compared with the non-supplemented group (67%). Survival rate was significantly ($P < 0.001$) affected by the type of birth, sex of lambs and year of birth. Ewes supplemented with high level (280 g/h/day) gained 3-4 kg over their mating body weight before lambing and 0.2-1 kg after lambing to weaning where as the non-supplemented ewes lost 1.3-2.4 kg from lambing to weaning. It was concluded that Horro ewes can be supplemented with 280g/h/day of concentrate starting six weeks prior to lambing for higher birth weight of their lambs and maintenance of body weight of ewes.

## Introduction

Ewes underfed during late pregnancy can have little milk and poor mothering ability at lambing. Results from studies elsewhere (Mellor, 1983 ; Holst *et al.*, 1986) suggest provision of adequate feed for ewes during the last trimester of pregnancy. Proper feeding regime of pregnant ewes during the second half of gestation ensures normal foetal development and better weight at birth (Dimiter, 1992). A significant influence of birth weight of lambs on early survival and on growth performance have been reported for temperate and tropical breeds (Ivanov, 1975; Geraled, 1977; Yohannes *et al.*, 1995). Thus, the size and strength of lambs can be considerably affected by the state of nutrition of ewes during late pregnancy. A practical feeding system should aim at fulfilling the ewes requirement through feeding, while at the same time ensuring moderate utilization of ewe's body reserves.

The Horro sheep of the western highlands of Ethiopia (1600-2200 m altitude, 9-11° N latitude 35°-38° east longitude) is characterized (Galal, 1983) as large, short haired, fat tailed breed, with fast growth rate of up to 140 g daily and lambing percentage ranging from 130-150 %.

However, the young mortality rate reported for this breed was as high as 37 % (Kassahun *et al.*, 1991; Yohannes *et al.*, 1995). Nutritional improvements in late pregnancy of ewes has been suggested as a measure to reduce young mortality through production of heavier and more viable lambs.

The present study was undertaken to investigate the effect of level of feeding pregnant ewes on growth and survival of lambs to weaning; the weight changes of ewes from mating and from lambing through weaning.

## Materials and Methods

*Animals and management*: The experiment was conducted from 1994-1996 using pure bred Horro sheep at The Bako Research Centre (1650 m altitude 09°6'N and 37°09'E latitude; 1200 mm annual rainfall). Animals grazed native pasture and some crop residues from 8.30 - 16.30 hours and were housed at night. Mating season was November/December of each year. Six weeks before lambing, pregnant ewes were stratified based on age and were randomly assigned to one of the following feeding treatments 0 , 140, 210, 280 g /head/day of concentrate supplement to lambing. After lambing, all groups were fed hay *ad libitum* and a maintenance ration of 200 g/head/day using the above concentrate mixture. The concentrate mixture consisted of 49% ground maize (8.9% CP) 49% noug-cake (*Guizotia abyssinica*, 35% CP) and 2% bone meal, blood meal and salt. Animals were kept indoors for one month after lambing. Ewes and lambs grazed together until weaning at 90 days, after which the lambs were segregated, but followed the same basic management system. Ewes were weighed every 28 days post partum; and lambs every 14 days up to weaning.

*Statistical analysis*: The least-squares model procedure of Harvey (1990) was used to analyze the data. The model incorporated the four levels of feeding (treatment), year, type of birth and sex of lambs as independent variables and birth wight, weaning weight, average daily gain and mortality of lambs as dependent variables. Ewe weight at mating, at mid-pregnancy and at lambing were fitted in the model as regression variables.

## Results

### *Birth weight*

Lambs born from ewes supplemented with high level (280g/head/day) of concentrate in late pregnancy were heavier at birth ($P < 0.001$); the values being 2.2, 2.5, 2.6, and 2.9 kg for non-supplemented, low, medium and high level of supplementation respectively. Type of birth and sex of lambs significantly ($p < 0.01$ and $p < 0.05$), respectively influenced birth weight. Year of birth also had a significant ($p < 0.05$) effect on lamb birth weight. Heavier lambs were born in 1994 ($2.6 \pm 0.05$ kg) and in 1995 ($2.6 \pm 0.03$ kg) than in 1996 ($2.4 \pm 0.05$ kg). The preweaning mortality was higher in 1996 (49%) than in 1994 (23%) and in 1995 (19%). This might be related to some environmental influences.

*Weaning weight*

Weaning weight (WWT) averaged 10.3±0.17 kg for all groups. The influence of maternal nutritional status on WWT was not significant ($P > 0.05$). However, WWT showed an increasing trend with increasing levels of late pregnancy feeding (9.8±0.36, 10.1±0.33, 10.4±0.33, and 10.9±0.38 kg for the level of supplementation from low to high level respectively). Single lambs were significantly heavier ($P < 0.001$) at weaning than twins (Table 1). The difference in weaning weight between sexes was not significant. Weaning weight was comparatively lower in 1996 than in the previous two years, but the differences were not significant.

Table 1. Least-squares means and SE for birth weight (BWT), Weaning weight (WWT), average daily gain (ADG) and percentage mortality to weaning in Horro lambs.

| Treatment | N | BWT(kg) | WWT(kg) | ADG(g) | Mortality(%) |
|---|---|---|---|---|---|
| Total | 283 | 2.6±0.03 | 10.29±0.17 | 102±2 | 31 |
| Supplement, g/h/d | | *** | ns | ns | ns |
| 0 | 67 | 2.2±0.05 | 9.8±0.36 | 98±4 | 33 |
| 140 | 75 | 2.5±0.05 | 10.1±0.33 | 100±3 | 30 |
| 210 | 83 | 2.6±0.05 | 10.4±0.33 | 103±3 | 30 |
| 280 | 58 | 2.9±0.05 | 10.9±0.38 | 107±4 | 29 |
| Type of birth | | ** | *** | *** | *** |
| Single | 154 | 2.7±0.04 | 11.6±0.22 | 115±5 | 19 |
| Twin | 129 | 2.5±0.03 | 9.0±0.04 | 89±3 | 42 |
| Sex | | * | ns | ns | *** |
| Female | 117 | 2.5±0.04 | 10.3±0.26 | 102±0.9 | 24 |
| Male | 166 | 2.6±0.03 | 10.2±0.25 | 102±0.2 | 37 |
| Year of birth | | * | ns | ** | *** |
| 1994 | 64 | 2.6±0.05 | 10.9±0.34 | 109±0.3 | 23 |
| 1995 | 122 | 2.6±0.03 | 10.9±0.24 | 108±0.8 | 19 |
| 1996 | 97 | 2.4±0.05 | 9.0±0.35 | 89±0.7 | 49 |

ns=not significant; * P<0.05; ** P<0.01; *** P<0.001.

*Average daily gain (ADG)*

The results summarized in Table 1 indicate that the factors which influenced average daily gain (ADG) from birth to weaning were basically similar to the factors which

influenced birth weight and weaning weight, except for year of birth which affected ($P < 0.001$) the average daily gain of lambs. Single born lambs grew faster ($115 \pm 0.5$ g/ head/day) from birth to weaning than twins ($89 \pm 3$ g/head/day) born lambs.

*Lamb mortality*

The mean preweaning mortality of Horro lambs over the three years of this study was 31%. There was a trend for better survival rate (71%) of lambs with increased level of late pregnancy ewe nutrition (Table 1). But the difference in lamb mortality between feeding levels, was not significant. Mortality was affected ($P < 0.001$) by type of birth and year of birth, with twins having less survival rate (58%) than singles (81%). Lamb mortality varied over the years, and was 23% in 1994, 20% in 1995 and 49% in 1996. Sex of lambs significantly affected survival rate, with mortality rates of 24% and 37% female and male lambs, respectively (Table 1). Ewe weight at mating, at mid-pregnancy and at lambing had no significant ($p > 0.05$) relationship with lamb survival to weaning.

Table 2. Analysis of variance for the effect of different factors on birth weight (BWT), weaning weight (WWT), average daily gain (ADG) and mortality (MOR%) of Horro lambs.

| Factored | df | BWt | WWt | ADG | Mor(%) |
|---|---|---|---|---|---|
| Feeding level | 3 | 4.2*** | 14.0 | 919.3 | 0.02 |
| Type of birth | 1 | 1.0** | 142.4*** | 29043.3*** | 18.69*** |
| Sex | 1 | 0.4* | 1.4 | 24.2 | 5.81*** |
| Year | 2 | 0.3* | 10.3 | 6549.2** | 12.98*** |
| Error | 189 | 0.1 | 5.6 | 562.8 | 0.19 |
| Regression | | | | | |
| Mating weight | | 0.95 | 7.964** | 7.81** | 1.17 |
| Mid pregnancy Weight | | 1.92 | .754 | .75 | 0.19 |
| Lambing weight | | 0.65 | 15.557*** | 15.46** | 0.56 |

* P<0.05 ** p<0.01 *** p<0.001

*Body weight changes of ewes*

Over mid-pregnancy and lactation, live weight change of ewes ranged from -2.4 to 4.1 kg in the control and high level supplemented group, respectively. Ewes supplemented with 280g/head /day (high) gained 3 to 4 kg over their mating body weight before lambing, and 0.2 to 1 kg from lambing to weaning. The control (non-supplemented) group however, started to loose their mating body weight before lambing at lambing, and after lambing (Fig 1).

## Discussions

The increase in lamb birth weight, with the feeding level of ewes in late pregnancy in this study could be due to better supply of nutrients to the uterus in well fed pregnant ewes compared to underfed ewes. Large reduction in the supply of growth substrate to the uterus and low concentrations of blood glucose have been reported in undernourished ewes (Mellor *et al.*, 1982). According to Vincent *et al.*, (1985) sever nutrient restriction of dam in late pregnancy caused low birth weight, growth retardation and low (58%) survival rate.

Weaning weight is a reflection of many factors, such as milk production of ewes and other environmental conditions. Horro ewes are reported to be poor milkers (Galal, 1983). However, the result of this study showed increasing trend of weaning weight with increasing

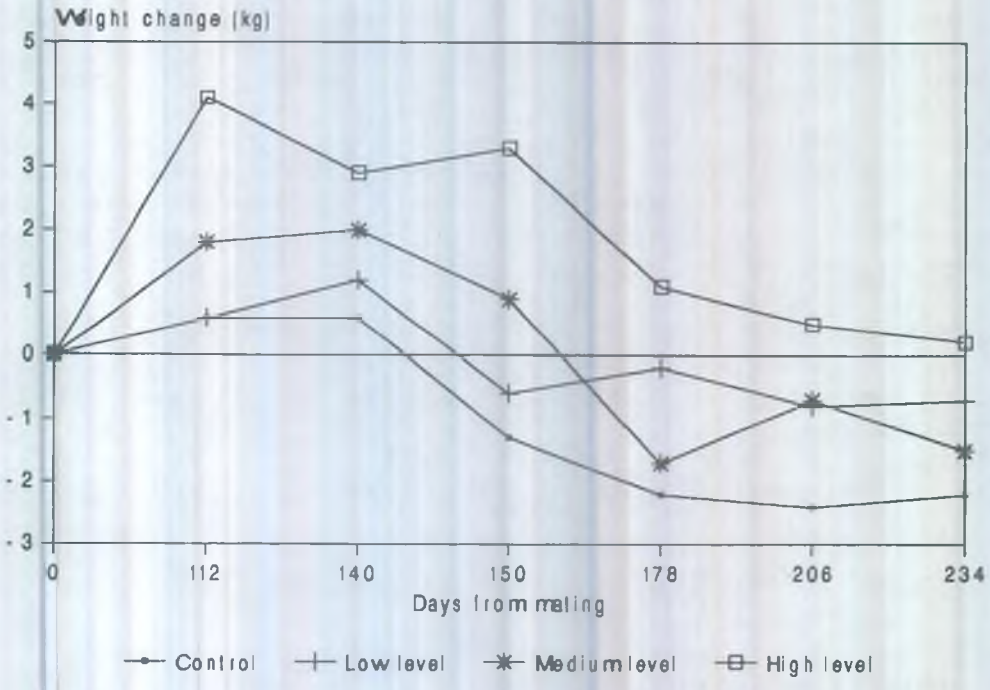


**Figure 1.** Weight change of ewes at different stages from mating to lambing and weaning

birth weight of lambs. This shows that, heavier birth weight of lambs would result in heavier weaning weight, if other environmental conditions are favourable. This also holds true for growth rate to weaning.

In this study, level of nutritional supplementation did not improve pre-weaning lamb mortality. However, through its influence on lamb birth weight, a tendency for decreased mortality to weaning was observed (Table 1). Gerald (1977) reported a similar result, but found that physical damage due to dystocia to be the main cause of death in heavier and single born lambs which has not been reported in the Horro breed so far. Lack of significant correlation between lamb mortality and the weight of dam at mating, mid-pregnancy, and at lambing is contrary to previous work of Kelly (1992) who reported significant correlation between mid-pregnancy weight of ewes and lamb survival rate to weaning. Causes of high mortality in Horro lambs could most probably be due to more of other environmental factors than maternal body weight during pregnancy and lactation. survival rate of twins (58%) was lower than singles (81%), and females survived better than males (76% vs 63%). This is in agreement with the findings of Solomon *et al.*, (1995) for the same breed at the same age.

Year of birth had a significant ($p<0.001$) effect on lamb mortality. The possible explanation for this could be fluctuations in weather conditions which might have exposed young lambs to wind draft (pneumonia) and heavy parasitic burden (Muktar *et al.*, 1991).

The fact that less fed ewes lost weight in the weeks before lambing reflects the high nutritional demand of pregnant ewes at this stage as reported earlier (Arnold *et al.*, 1977; Oddey and Holst 1991; Kelly, 1992).

## Conclusions and recommendations

The result from this study showed that increasing birth weight of Horro lambs results in better survival rate. One of the ways of increasing lamb birth weight is to improve the feeding management of ewes during late pregnancy. Horro ewes supplemented with 280 g/head/day of concentrate mixture consisting of 49% maize, 49% Noug-cake and 2% salt plus bone and blood meal starting six weeks prior to lambing, had heavier lambs at birth and good body weight. Moreover, from the view point of improving productivity of Horro sheep, pre-weaning survival rate improved with increased late pregnancy ewe feeding. Nevertheless, the mortality rate found in this study is still high and close to previous reports (37%). This suggests further investigation on the causes of the high young mortality of Horro sheep.

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# Traditional Sheep Management and Production Situation in The South Western Part of Ethiopia

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## Abstract

This study was conducted in the Jimma Zone of southwestern part of Ethiopia to assess the traditional sheep management and routine husbandry practices and the flock composition. The most important husbandry practices established in this study include housing, feeds and feeding, disease situation, lamb rearing, castration, mating management and some problems facing sheep production. The livestock composition in the zone is 47.4%, 45.9%, 3.8%, 3.0% cattle, sheep, goats, and equine, respectively. Of the total sheep enumerated, ewes constituted 54.4%, ram 8.6%, lambs 34.3% and castrates 2.8%. The ewe to ram ratio recorded for the zone is 6.3 to 1. The average flock size is 4.2. The main source of feed is natural pasture supplemented with crop residues and crop aftermath. It was also noted that, in the wet season, farmers tether their flock to avoid crop damage. The most common diseases reported from the description of symptoms of diseases include pneumonia, liver fluke, parasite of the lungworms, diarrhea in order of importance. The most common problems indicated by the farmers related to sheep production, in order of importance are diseases and parasites, shortage of feed, labor scarcity and predators.

## Introduction

Southwestern part of Ethiopia is characterized by a cash crop (coffee and chat) and cereal- livestock diversified agricultural production system. Some of the efforts by the government and non-government organizations to improve the living standards of the rural community are directed towards the improvement of cash crops. No major effort has been put forward to consider the over all farming system. As a result, the region is severely suffering from poor extension system and lack of inputs in the livestock sector. But, there is clear evidence that livestock play a vital role, first as a source of milk and meat to the household and second as a source of income in time of need. Their importance in the provision of meat, milk and income is profound when there is a drastic drop in coffee price and during period of cash crop failure.

In this cash crop growing region, sheep form an important component of the livestock production system. However, information on the traditional husbandry and management system is scarce. Studying the socio-economic aspect of the household, sheep management and husbandry practices, the constraints to sheep production and the interaction of sheep farming with other farming activities is important before developing innovations for improving sheep production system.

This study therefore, focuses on current sheep management and husbandry practices in nine selected villages of four districts in southwestern Ethiopia. Based on the results of the survey, some 200 farmers (flocks) will be selected for further monitoring for a period of two to three years to test their productivity under village management condition. The objectives of this study were to analyze the sheep production systems, husbandry practice and to identify constraints related to sheep production. It is hoped that the information sought from the farmers would provide the basis for intervention with technological innovations and help to design appropriate development strategies, which complement other farm activities.

## Materials and methods

The study was conducted in one of the cash crop growing areas of the southwestern Ethiopia. Nine-peasant associations (PAs) located within a radius of 25 km from Jimma were selected as a target group. Initially consultation was made with district livestock officers, and PAs were selected based on accessibility, potential for sheep production and farmers interest in the proposed study. Within the selected villages, all farmers owning sheep were registered and 30 farmers were selected randomly for an interview. A questionnaire designed to generate information related to housing, watering, feeds and feeding, flock structure and composition, sheep production constraints, disease prevalence and disease control and treatment practices were pretested using a few farmers. Questions were framed in such a way that farmers could provide information that were recent and easy to recall. All species of livestock were included in the survey for the purpose of establishing livestock composition whereas detailed information was collected on sheep. Four enumerators were involved to carry out the survey from June to August, 1995. The data were coded and analyzed using minitab 6.1 version with an option of discrete statistics. Comparisons were made purely on percentage or absolute number basis.

## Results

*Composition of livestock, flock size and structure*

The livestock composition in four surveyed Woredas for cattle, sheep, goat and equine is 47.4%, 45.9%, 3.8% and 3.9%, respectively ( Table 1). Sheep, goats and equine rank from second to fourth in composition.

Table 1. Composition of livestock holdings in four Woredas

| Species | Number | % Total livestock |
|---|---|---|
| Cattle | 1320 | 47.4 |
| Sheep | 1278 | 45.9 |
| Goat | 105 | 3.8 |
| Equine | 84 | 3.0 |

Of the total sheep enumerated, ewes constitute ( 54.4%), rams constitute 8.6%, lambs comprise 34.2% and castrates constitute 2.8% ( Table 2 ). In terms of sex classification the percent composition of females, entires and castrates is 77.2%, 20% and 2.8%, respectively. The sex percentage of lambs is 66.8% females and 33.2% males. The ewe to lamb ratio computed in this study is 6.3 to 1. The average flock size in the study area is 4.2. the maximum being 24 and the minimum 1 (Table 3).

Table 2. Sheep population and composition

| Class | Number | % Total Sheep |
|---|---|---|
| Ewes | 695 | 54.4 |
| Rams | 110 | 8.6 |
| Female lambs | 292 | 22.9 |
| Male lambs | 145 | 11.4 |
| Castrates | 36 | 2.8 |

*Management*

The management components studied included housing, feeding, watering, disease control, lamb rearing, mating management, disposal and grazing practices.

*Housing*

About 83.9% of the farmers confine their sheep in a room which is part of the main family house and 8.7% housed their sheep in an adjoining house, while 7.1% put their sheep in a separate shelter constructed close to the main family house. There was no farmer who freely put his/her sheep in the grazing area (open kraals). This study indicated that about 71.2% of the respondents tied their sheep in their house and use it during the night, when heavy rain prevails and when there is extreme heat. About 95.0% the farmers house their sheep separately from other classes of livestock.

*Feeding*

The main source of feed was natural pastures, which grow in fallow lands, boundaries of cultivated areas, road and riversides. About 99.7% and 98.0% of the farmers in the area indicated natural pasture to be the main feed resource during the wet and the dry season, respectively. The second major feed resource was fallow land, which was utilized by 74.7% and 53.7% of respondents during wet and dry season, respectively. During the dry season, crop aftermath was mentioned as source of feed by about 83.8% of the farmers. There was no improved forage introduced in the small ruminant feeding system in all the villages studies. The use of hay and crop residues as a dry period feed is not common.

The importance of providing mineral licks to sheep and other animals is well recognized. About, 94.4% of the farmers interviewed responded that they use salt, especially during the wet season to increase feed intake. Sheep generally graze for about 9 hours ( 8 AM to 5 PM) and are watered at mid-day. The major source of water is a river (80.2%) located about 1 km from the homestead. About 53% of the sheep were trekked to water source and only 38.2% were provided water at home, mainly during the wet season when animals are tethered.

*Management systems*

The two management systems identified in the wet and dry season were semi-extensive and semi-intensive . In the semi- extensive system, sheep are tethered in the field during the day and confined at night. In the semi- intensive system sheep are confined at night, during heavy rains and during strong heat in the day and tethered in the field the rest of the day. Access to fresh grass is made available by regular shifting the tethering pegs by family members. Farmers practice tethering during the wet season to control crop damage and to keep sheep from predators or theft. Farmers are involved in heavy agricultural activities during the wet season.

Table 3. Average flock size, sex composition and ram to ewe ratio in four Woredas

| | | Woreda | | | |
|---|---|---|---|---|---|
| Particular | Total | Yebu | Seka | Dedo | Serbo |
| No. Study area | 9 | 1 | 2 | 4 | 2 |
| No. farmers | 301 | 33 | 85 | 138 | 45 |
| Total sample | | | | | |
| - % females | 77.2 | 73.1 | 77.5 | 80.4 | 68.7 |
| - % male | 19.9 | 21.2 | 22.5 | 16.8 | 25.4 |
| - % castrates | 2.8 | 5.8 | 0.0 | 2.8 | 5.6 |
| Average flock Size | | | | | |
| - mean | 4.2 | 2.7 | 4.0 | 4.8 | 4.2 |
| - minimum | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| - maximum | 24.0 | 7.0 | 12.0 | 24.0 | 10.0 |
| Lamb sex % | | | | | |
| - female | 66.8 | 60.0 | 43.9 | 63.6 | 54.9 |
| - male | 33.2 | 40.0 | 16.1 | 36.4 | 45.1 |
| Ratio | | | | | |
| - ewes | 6.3 | 12.3 | 2.9 | 10.7 | 6.6 |
| - rams | 1 | 1 | 1 | 1 | 1 |

*Diseases and disease control*

The most common diseases, noted from the description of symptoms of diseases, included pneumonia, liver fluke, GIT worms, lung worm, diarrhea, circling disease, and foot rot (Table 4). Farmers mentioned that pneumonia, liver fluke, GIT worms and lungworm in that order, as the most common diseases in their flocks. About 59.1% and 72% of the farmers indicated that they use traditional and modern medicaments, respectively. The sources of the modern medicaments are the MOA (59.7%) and open markets ( 17.4%).

Table 4. Disease symptoms (%) described by owners of sheep as summarized from the questionnaires

| Disease symptoms | No. respondents | % respondents |
|---|---|---|
| Pneumonia | 237 | 79.8 |
| Liver fluke | 232 | 78.1 |
| Diarrhea | 122 | 40.6 |
| Foot rot | 18 | 6.1 |
| Circling disease | 59 | 19.8 |
| GIT worms | 132 | 44.3 |
| Lung worms | 112 | 42.6 |

*Lamb Rearing*

The majority of the farmers keep newborn lambs and their dams in the house for 12 to 24 hours after birth. The farmers mix the lambs to the flock after 2 months. Before mixing of lambs with a flock, fresh grasses and tree leaves are provided and the lambs suckle when the ewes are brought to the house for confinement. As to weaning practice About 27.6 % of the farmers practice gradual weaning to avoid stress on pregnant ewes while 69.7 % do not get involved. Children are more responsible to look after lambs in the house.

*Castration*

Castration of ram lambs is practiced by about 47.3% of the farmers. The age at castration is about 1.5 years. The reason for castration is to get the highest sale price at later stages. About 71% of the respondents castrate their ram lambs using stones, sticks or handle of a sickle to crash the vas deference of the testes. About 28.5% of the total farmers take their ram lambs to the Ministry of Agriculture Veterinary clinics for castration. Almost all farmers (92.0%) provide extra feed to the castrates ensure better weight gains.

*Culling*

About 94.2% of the farmers indicated that they maintain their sheep to generate cash income during the period of financial difficulties. Keeping of sheep for home consumption and gift for relatives is negligible. The primary reason for (97.0%) disposal or culling of sheep is to generate income. The sheep classes sold are male lambs, castrates, old ewes and unfertile ewes in that order of preference.

*Mating management*

Most farmers maintain ram to ewe ratio of 1 to 6. The rams and ewes are tethered during the day and confined and tied in the house at night. Mating occurs when the ewe shows sign of heat and at this time the ram is released for service. The average age of ram lambs and ewe lambs at first mating is 9 and 11 months, respectively. About 97% and 75.9 % of the farmers indicated that they could detect estrus of ewe and recognize male lambs to reach puberty, respectively. Some farmers control breeding of ram lambs and ewe lambs. They control mating to minimize weight losses and poor conformation in ewes, which is reflected in market prices. They control early mating of ewe lambs to avoid early production of unthrifty lambs. It was not the intention of the farmers to practice controlled breeding to avoid the risk of inbreeding depression. The sources of ram for breeding is from own flock, purchased/borrowed, or from both sources. The probable reproductive life span of an ewe is about 8.4 years and by this age ewes are expected to have lambed about 10 times.

*Major constraints*

The farmers interviewed in the study area indicated their concern not to keep more sheep in their flock ( Table 5). The problems that have frequently mentioned to hamper the expansion of sheep flock size are diseases and parasites, shortage of feed, shortage of labor, predators and preference to other classes of livestock in that order.

*Desirable and undesirable merits of sheep*

The respondents were asked to enumerate the most appreciated features of sheep rearing ( Table 6). About 59.1% of respondents designated that prolificacy and rapid reproductive cycle to be the good attributes of sheep rearing. Similarly, about 83.9% of the respondent praised sheep for their quick return, 28.5% for their low feed requirement and 22.5% for their ease to handling. When the respondents were asked to indicate undesirable attributes of sheep, about 24.2% mentioned that sheep are susceptible to diseases and parasites, and about 17.4% mentioned that sheep are victims of predators.

## Discussion

The small flock size (x = 4.2) recorded in this study is a typical example of sheep keepers that tether their sheep during the crop growing seasons. Comparable results (x=3) have been recorded in south Nigeria ( Matthrewman, 1980; Sumberg, 1985). However, the average flock size of 5.6 recorded in Debre Berhan by Agyemangy *et al.* (1985) is different from this study. In Debre Berhan sheep are a dominant species and are reared in communal grazing area and tethering is not practiced. Of the flock studied, 77.2% constituted females and about 66% of the total flock was comprised of females of breeding age. This confirms the earlier finding of Wilson (1980, 1986); and Agyemang *et al.* (1989) who showed that such stability of flock structure is obtained by early culling of males not required for other productive functions. On the contrary, Wilson (1980) reported that in the Afar region females constitute 92% of the flock and attributed this to the fact that, Afar people are entirely dependent on milk and kill male sheep at birth. The high sex ratio of lambs in favor of female lambs in this study indicates an early disposal of male lambs to get financial return.

The region is known to practice tethering of sheep during the wet season. This is because such a widely practiced management system is essential to protect growing cereal and cash crops from damages by sheep, to use labor efficiently and to use the land properly. Similar observations have been made by Workneh ( 1991) in densely populated agricultural systems in southern parts of Ethiopia. The drawbacks of such a management system include stringing of sheep with the rope, the need for frequent shifting (labor intensive), avoidance of selective feeding and trampling of the grazing area. Therefore, there is need to further investigate the prone and cons of tethering.

The scarcity of adequate feed in the study area justifies a research program on nutritional studies within the farming system. A studies on feed inventory and techniques of feed preservation (haymaking and proper collection of crop residues) applicable to the local objective condition is suggested. The introduction of browse legumes for planting in back yards and in boarder lines of cultivated areas will provide supplementary feeds for small ruminants during the wet season and serve as a hedge and source of fuel wood. Tree legumes should be planted during the wet season when sheep are tethered so that there will be a better chance for establishment and provide foliage during the dry season.

Based on diseases symptoms described by the farmers, it was noted that pneumonia and flukes are the main diseases. The other diseases include GIT worms, lungworm and diarrhea. This result is consistent with previous findings in other parts of Ethiopia (ILCA, 1986; Tekleye *et al.*, 1992). Pneumonia is frequent during the long rainy season in young than in adult sheep. This is probably due to some stress factors such as cold weathers, which exasperated the situation ( Tekelye *et al.*, 1992). In this study laboratory confirmation on the various diseases could not be established. Therefore, there is a need to confirm the causative agent's diseases and take cost

effective veterinary measures. It was clear from this study that there is an occasional use of veterinary drugs purchased from either open markets or from MOA veterinary clinics. Such occasional veterinary treatment is ineffective and potentially dangerous. The disease problems could partially be prevented by proper management and by making available the antihelmenthics in service cooperative veterinary clinics.

Table 5. Constraints to expand sheep flock as prioritized by respondents

| | Priority Order % | | | | | |
|---|---|---|---|---|---|---|
| Constraints | 1st. | 2nd. | 3rd. | 4th. | 5th. | 6th. |
| Diseases | 36.6 | 30.9 | 25.0 | 6.0 | 1.5 | - |
| | (98) | (83) | (68) | (16) | (4) | - |
| Pasture/Feed | 25.0 | 37.2 | 20.8 | 12.8 | 3.2 | 0.8 |
| | (63) | (93) | (52) | (32) | (8) | (2) |
| Labor | 10.2 | 7.5 | 21.8 | 35.0 | 24.5 | 0.7 |
| | (15) | (11) | (32) | (51) | (36) | (1) |
| Financial | 36.3 | 21.6 | 21.6 | 9.1 | 10.2 | 0.4 |
| | (89) | (53) | (53) | (24) | (25) | (1) |
| Predators | 15.6 | 20.8 | 21.4 | 16.8 | 23.7 | 1.7 |
| | (27) | (36) | (37) | (29) | (41) | (3) |
| Preference | 8.1 | 12.2 | 9.5 | 29.7 | 12.2 | 28.4 |
| | (6) | (9) | (7) | (22) | (9) | (21) |

* Figures in parenthesis are the number of respondents

Table 6. Desirable attributes of sheep compared to other classes of livestock.

| Particular | No. respondents | % respondents |
|---|---|---|
| Prolificacy | 176 | 59.1 |
| Quick return | 250 | 83.9 |
| Low investment | 15 | 5.0 |
| Ease of handling | 67 | 22.5 |
| Lower feed req. | 85 | 28.5 |
| Growing demand | 44 | 14.8 |

In such a small sized flock per household, one could expect inbreeding to an extent in which the offspring could serve the dam. Uncontrolled breeding could lead to early breeding of females resulting in low conception rate, low birth weights and poor survival rates. Inbreeding and early conception could be avoided by separating the sex groups and by early castration of male lambs that are not needed for breeding. Exchanging breeding rams could also play a significant role in avoiding inbreeding in a small flock.

## Conclusion

The flock size maintained by the farmers is small due to primarily feed shortage. To alleviate feed shortage there is an urgent need to take feed inventory and introduce some tree legumes in the cropping system without leading to a serious competition with cultivated land. The very common management system adopted in the wet season is tethering which calls upon a systematic study on its effect on productivity, feed utilization and labor efficiency.

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# Preliminary Investigation on the Seasonal Occurrence of Ovine Parasites Around Sheno

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## Abstract

Faecal samples were collected monthly from 504 Ethiopian highland sheep kept on station and in six farmers' villages around Sheno Agricultural Research center during the period May 1995 - April 1996. Samples were examined microscopically to determine the class & species of parasites involved and the number of gastrointestinal nematode eggs per gram of faeces (EPG) using the sedimentation and floation techniques. Baerman techniques was also used to isolate infective larvae of *H. contortus* in faecal cultures from on-station animals. Eggs of *Fasciola*, *Paramphistoma*, moniezia and gastrointestinal nematodes (strongyle), and larvae of *Dictyocaulus filaria* and *Muellerius capillarius* were identified as the prominent internal parasites of sheep in the Sheno area. Monthly prevalence of positive trematodes, cestode and lung nematodes indicated that maximum infection rates with *Fasciola*, *Paramphistoma*, Moniezia spp., D. filaria and M. capillarius were 47.6% , 50%, 23.8%, 6.7% and 30.9%, respectively. Peak intensity of lung nematodes occurred during the long rains from June to August and during the short rains from February to March. High prevalence rates of *Fasciola* occurred form April to June and in January. Mean EPG count of gastrointestinal nematodes varied from 103 in April to 879 in August. Differences in prevalence rates were observed due to variables such as sex, age, health status and faecal consistency. Mean monthly rainfall and monthly strongyle counts were found to be positively associated.

In general, strongyle faecal egg count and lung nematodes peaked during the long and short rainy seasons whereas the prevalence rate of *Fasciola* increased during the dry season in the months of January, April and May. It would, therefore, be effective to strategically de-worm animals at lush seasons and at least twice a year just before the on-set of the short and long rainy seasons (mid- June and mid-January) in-order to reduce worm burden and pasture contamination with eggs/larvae.

## Introduction

With a population of 21 million sheep (FAO, 1994), Ethiopia stands second among African nations and 6th in the world. In the cool tropical highlands of Ethiopia, where smallholder mixed crop-livestock is a dominant mode of production system, sheep are the major livestock species kept, with no supplementary feeding and minimum health interventions. Like in many tropical areas, the predominant feed source is natural pasture grazing in seasonally water-logged areas, marginal lands, and fallow lands.

Among animal health problems constraining sheep production gastrointestinal parasites (nematodes, trematodes and cestodes) are the major ones. These parasites result in clinical and sub clinical infections causing low productivity due to stunted growth, inefficient weight gain, poor feed utilization and mortality (Sykes, 1978; Barger, 1982; Armorr and Gettinby, 1983; Tekelye, 1991). Some parasites are predisposing factors for the development of other diseases such as verminous pneumonia (Tekelye, 1992). There are several studies on internal parasites in the highlands of Ethiopia (Mamo et al., 1981; Lemma et al., 1985; Njau et al., 1988, 1990; Tekelye 1987; 1988; 1991 & 1992; Ayalew, 1995). However, there is no adequate information on the various factors influencing the transmission and the extent of seasonality of gastrointestinal parasites under the traditional production system in order to be able to establish effective and feasible parasite control strategies. On the other hand, the dominant parasites in an area can change, particularly as livestock management practices change, so existing parasite inventories as well as distribution data based on previous studies may require up dating (Hansen and Perry, 1992). This study was conducted from May 1995 to April 1996 to determine the seasonal pattern and level of gastrointestinal parasite infection under the traditional management system in the Sheno area.

## Materials and Methods

The study was conducted on-station and in six adjacent villages around Sheno [Yegdu, Kottu, Cheki, Dalota, Chacha (1) and Chacha (2)) within 30 km radius of the Sheno Agricultural Research Center (SARC) from the period of May 1995 to April 1996. the study area is a plateau located in the cool highlands of north Shoa at an altitude ranging from 2700 - 2850 m asl. The site receives annual rainfall of about 870 mm (average for 15 years) on the average with the bimodal pattern consisting of a long rainy season from June to September in which 80 percent of the annual rainfall occurs and a short rainy seasons from February to March. Average minimum air temperature is 5.6 °C and frost usually occurs in the months of November and December when the average minimum air temperature reaches 0.3°C - 2.7°C. The maximum air temperature averages 18.6°C and the mean annual humidity is 68.2% (Sheno Agricultural Research Center, 1994 unpublished data). All sample locations are in the mixed crop-livestock farming system. They are categorized as a well drained, uphill (Yegdu and Dalota) and table lands characterized by intensive cropping with fallow lands for grazing. Poorly drained, water logged, low grounds around drainage lines which are not suitable for cropping are used for grazing (Chacha 1 & 2, Kottu and Cheki sample sites). The dominant grass is Pennisatum spp. and the soil class is pellic vertisol with pH of 6.2.

A total of 504 sheep (6 animals /site/month) of different owners closer to road were examined at convenience with cooperation of owners. Faecal samples were taken from rectum once a month from representative sheep in all the sites. The age, sex, health status and faecal consistency of all sampled animals were recorded and examined for strongyle eggs and coccidia oocyst using modified Mcmaster technique as described by Soulsby (1982). Trematode eggs were examined using Brumpts sedimentation technique (C.A.B., 1989). Information on the type of adult helminths infesting the sheep was collected during routine necropsies of the on-station animals that had died from acute or chronic parasitosis using a postmortem examination. Of

the 504 animals used for this study, 120 male and 384 female animals were examined for both EPG count and prevalence rates of trematodes and lung nematodes in different categories of animals. Three hundred nine young and 195 adult animals were also used to determine the occurrence of trematodes and lung nematodes, whereas 145 young and 359 adult animals were used for EPG count. Age estimation for each sampled and necropsied animal was made by dental formula (Gatenby, 1991).

**Results and Discussion**

Out of the 504 faecal samples examined *Fasciola hepatica* and *Paramphistoma* eggs, egg of *Moniezia* spp., larvae of *Dictyocaulus filaria* (Df) and *Muellerius capillarius* (Mc) and eggs of *Strongyle* were identified as the prominent internal parasites in all the sites.

Maximum infection rates with *Fasciola*, *Paramphistoma*, *Moniezia*, D.f & M.c species were 47.6, 50, 23.8, 6.7 & 30.9%, respectively (Table 1). Peak infection of lung nematodes occurred in August for Df, whereas Mc was mainly diagnosed during the short rains (February-March) and Df during the long rains (June-August). The peak prevalence rate of *Fasciola* occurred in January, April and May (short rainy season).

**Table 1. Monthly prevalence of internal parasites at seven sites around Sheno**

| Month | Animals examined | % Positive | | | | |
|---|---|---|---|---|---|---|
| | | *Fasciola* | *Paramph-istoma* | *Moniezia* | Df | MC |
| May-95 | 42 | 47.6 | 42.0 | 23.8 | 0.0 | 7.1 |
| June | 42 | 42.9 | 28.6 | 7.1 | 16.7 | 19.0 |
| July | 42 | 26.2 | 19.0 | 4.8 | 14.3 | 11.9 |
| August | 42 | 26.2 | 31.0 | 7.1 | 16.7 | 30.9 |
| September | 42 | 40.5 | 16.7 | 0.0 | 9.5 | 16.7 |
| October | 42 | 14.3 | 23.8 | 11.9 | 9.5 | 9.5 |
| November | 42 | 26.2 | 19.0 | 16.7 | 7.1 | 16.7 |
| December | 42 | 38.1 | 19.0 | 2.4 | 11.9 | 9.5 |
| January-96 | 42 | 45.2 | 35.7 | 9.5 | 7.1 | 7.1 |
| February | 42 | 28.6 | 50.0 | 9.5 | 9.5 | 23.8 |
| March | 42 | 31.7 | 33.3 | 9.5 | 7.1 | 21.4 |
| April | 42 | 45.2 | 26.2 | 16.7 | 7.1 | 7.1 |
| Mean | 42 | 34.7 | 28.7 | 9.9 | 9.7 | 15.1 |

Mean egg count of strongyle varied from 103 to 879, ranging from 0-8000 eggs, with peaks in August and March (Table 2). The mean minimum EPG 103 was recorded in April. High mean egg of strongyle (1900) and( 916.7) were observed at Kottu and Chacha sites with low mean epg (425) at on-station. Among the various animal characteristic categories (Table 4), remarkable differences were observed for *Fasciola* infection between young (44.33%) and adult (34.87%); sick (65.14%) and not sick (18.54%); diarrhoeic (37.56%) and pelleted faeces (32.51%). Young sheep (15%) were more prone than adult (6.1%) by D.f.

Appreciable differences in EPG count was also observed between health status group of animals. Mean EPG count was 893 for 98 sick animals and 184 for 406 not sick animals (Table 3). Different factors influence the egg out put of GI parasites. These include the age of the host, the spp. and age of the parasite population, the overall health status of the host (including the nutritional level), and physiological factors such as pregnancy and previous exposure to parasites (Tekelye *et al.*, 1987).

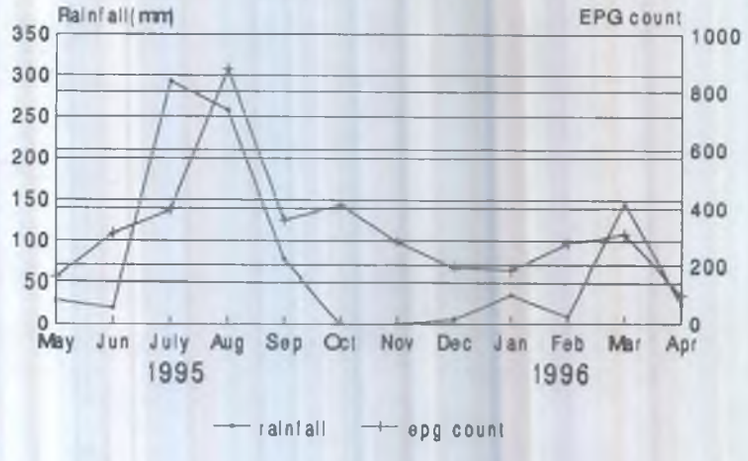
Table 2. Mean monthly strongyle EPG count and range at seven sites around Sheno

| Month | Animals examined | EPG(mean) | EPG (range) |
|---|---|---|---|
| May 1995 | 42 | 158 | 0-1250 |
| June | 42 | 312 | 0-1550 |
| July | 42 | 394 | 0-1550 |
| August | 42 | 879 | 0-8000 |
| September | 42 | 358 | 0-1350 |
| October | 42 | 411 | 0-2550 |
| November | 42 | 282 | 0-1150 |
| December | 42 | 193 | 0-650 |
| January 1996 | 42 | 183 | 0-850 |
| February | 42 | 277 | 0-800 |
| March | 42 | 311 | 0-2900 |
| April | 42 | 103 | 0-750 |
| Mean | 42 | 322 | 0-1946 |

The relationship between mean rainfall (RF) and mean monthly strongyle egg count showed a positive correlation (Fig.1). The peak mean strongyle EPG followed the bimodal rainfall pattern in the area. The first peak occurred during the long rainy

season (August) and continued until the early dry season of October. The second peak occurred during the short rainy season in (February-March). Besides the prominent internal parasites identified by faecal examination, routine necropsies were carried out on-station and revealed that cysts of *Coenuriasis cerebralis* (multiceps multiceps), *Cysticercus tenicolis*, *Stilezia* spp., *Moniezia* spp., *Haemonchus contortus*, *Fasciola hepatica*, *Dictyocaulus filaria*, *Trichuris* spp., were the worms frequently encountered. Infective larvae of *Haemonchus contortus* was also detected by cultural development using Baerman technique on-station. Although lung worms were best recovered and quantified by the Baerman apparatus, in this study it was recovered from faeces suspended in water over night at room temperature, whereas faecal culture preparation started at the end of the study period with the late arrival of an incubator at the Center.

Fig.1 Relationship between mean monthly rainfall and mean monthly EPG count of sheep around Sheno




This finding is in agreement with Njau *et al.* (1990) who reported that some sheep in the flock passed low number of strongyle egg through out the year. However, the low levels presently encountered, in contrary to previous works of Njau *et al.* (1988), caused morbidity as reflected by sick (65.14%), not sick (18.54%), pelleted (32.15%) and Diarrhoeic faeces (37.56%). All egg counts were influenced by the consistency of the faeces; wet faeces being much heavier than drier specimens. Egg counts may vary widely between individual animals in a flock and it is wise to examine a number of samples from both clinically ill and apparently normal animals. Of course, the diarrhoeic consistency of faeces could be due to the feed type, other infectious diseases and damage of the lumen of intestine. The clinical cases observed despite low worm epg reflected the increased susceptibility of the sheep to gastro-

intestinal parasites was also communicated earlier by of Njau *et al.* (1990). The level of *Fasciola hepatica* was also higher, in agreement with the findings of Lemma *et al.* (1985). As it was justified by Lemma *et al.* (1985) the highest incidence of infection was observed 4.5 months after the beginning of the long rains due to peak period of snail population in mid August and infections of snails by *F. hepatica* development stages found the end of September. Besides, the low lying areas in the highlands have poor drainage and the soil seems to be acidic which favor the development of *Fasciola* in the area.

Table 3. Mean strongyle EPG for different categories of sheep in seven sites around Sheno May 1995-1996

| Category | Animals examined | Mean EPG |
|---|---|---|
| Sex : | | |
| Male | 120 | 257 |
| Female | 384 | 342 |
| Age : | | |
| Young (< 1yr) | 145 | 251 |
| Adult(> 1yr) | 359 | 350 |
| Health status | | |
| sick | 98 | 893 |
| not sick | 406 | 184 |
| Faecal consistency | | |
| Pelleted | 283 | 296 |
| Diarrhoeic | 221 | 355 |

The high prevalence of *Fasciola hepatica* during the dry season could be due to out breaks of clinical disease of trematodes which may occur during the short rainy season when large numbers of animals and snails concentrate around perennial natural ponds, streams and water holes. Infestation of sheep with lung nematodes depend on the season of the year. As seen in Table 1 percent positive of sheep with Mc examined during the different periods of the year varied from 7.1% (June and April) to 30.9% (August). The highest infestation of sheep with Df was marked between June and August (16.9%). Data on the age, sex, health status and faecal consistency are given in Tables 3 and 4. Results in these tables show that young animals (15%) are infested with Df twice more than adult sheep. Results of the age of infestation with Df indicated a high degree of pre disposition of lambs in comparison with adult sheep. We didn't find an interconnection between infestation of sheep with Mc in different

seasons of the year for different categories of age, sex and other factors. This is due to the fact that the duration of parasitizing of Mc in the organism of sheep may account for 5-6 years (Kassai, 1962). When infested once, the sheep therefore remains to be a carrier of these helminths for a long period of time and the seasonal dynamics of the invasion is not expressed. The high prevalence of Moniezia during the dry season could be related to the long life of contamination of pasture by Moniezia (the parasite can exist in the intermediate host for a period of up to 15 months). Observable differences in the occurrence of helminths in sheep in the sites was due to irregular health management interventions. The low strongyle EPG and minimum percentage of positive trematodes, cestode and nematodes on-station could be due the regular drenching regimes. The regular drenching regimes at the Center is drenching 3 weeks before mating (for breeding females and males), 10 days before parturition, lambs until 6 months of age at 4-6 weeks interval, 3-4 weeks after the first rains (for growing stock greater than 6 months) and every 4-8 weeks during the rainy season and to all sheep at the peak of the lush season.

Table 4. Age, sex, health status and faecal consistency prevalence of Trematodes and lung nematodes in seven sites around Sheno

| Variable | *Fasciola* | | | Df | | |
|---|---|---|---|---|---|---|
| | No. Examined | No.infected | % infected | No. examined | No. infected | % infected |
| Sex | | | | | | |
| Male | 120 | 42 | 35.0 | 120 | 11 | 8.1 |
| Female | 384 | 133 | 34.6 | 384 | 38 | 9.9 |
| Age | | | | | | |
| Young | 309 | 137 | 44.3 | 195 | 30 | 15.3 |
| Adult | 195 | 68 | 34.9 | 309 | 19 | 6.1 |
| Health status | | | | | | |
| sick | 175 | 114 | 65.1 | 175 | 17 | 9.7 |
| not sick | 329 | 61 | 18.5 | 329 | 32 | 9.7 |
| Faecal consistency | | | | | | |
| Pelleted | 283 | 92 | 32.5 | 283 | 27 | 9.5 |
| | 221 | 83 | 37.6 | 221 | 22 | 10.0 |
| Diarrhoeic | | | | | | |

Table 5. Topographical category of sample sites

| Topographical Category | Sample sites |
|---|---|
| Well drained (Up-hill) | Yegdu and Dallota |
| Poorly drained (water-logged) | Chacha (1&2), Kottu and Cheki |

This preliminary investigation on internal parasites around Sheno showed that the prevalence of a wide range of gastrointestinal parasites encountered both in faecal and necropsy findings in which Trematodes, GI nematodes and respiratory parasites are the most prevalent helminths and this is in agreement with the previous works of Njau *et al.* (1990); Tekelye *et al.* 1992; Ayalew (1995).

Based on the result of this experiment, further investigation of faecal culture in the area is recommended to identify the generic composition of strongyle. Parasite worm burden count should also be carried out for the already identified helminths. It was established that GI nematodes egg count and positive lung nematodes peaked during wet periods (July-August) of the long rains and the warm periods (February-March) of the short rains. January, April and May were the lush seasons favourable for *Fascioliasis*. It is therefore, recommended that de-worming should be done just before the rains (mid-June) for the long rains and mid-January for the short rains in-order to reduce pasture contamination by nematodes during the wet season. Prevention/control measures against *Fascioliasis* are also recommended at peak seasons (early dry and late dry) to reduce pasture contamination by mature and immature flukes during the dry season. This study indicated the importance of GI parasites in general and infection due to *fasciola* in particular. Based on the egg count, sheep flock in the area should be drenched using broad spectrum anthelminthic against GI parasites before the on-set of the rainy season to clear parasite burden acquired during the rainy season. However, further research is required to develop a comprehensive and economically feasible parasite control and prevention measures through strategic de-worming combined with vaccination against other infectious diseases and improved sheep husbandry practices.

Table 6. Mean maximum monthly EPG count across seven sites around Sheno

| Site | Critical months of infestation | Mean maximum EPG count |
|---|---|---|
| Chacha (1)[a] | August | 916.7 |
| Chacha (2)[b] | August | 766.7 |
| Cheki | August | 750.0 |
| Dalota | August | 691.7 |
| Kottu | July | 1900.0 |
| Yegdu | August | 933.3 |
| On-station | June | 425.0 |

[a] A grazing area before Chacha town
[b] A grazing area after Chacha town

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# Observation on Mortality Rates of Local and Crossbred Cattle at Holetta Research Centre

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## Abstract

The mortality rate of 1620 animals born at the Holetta Research Centre from 1974 to 1995 was studied. The study was based on animals that died between birth and 10 years of age. The breeds were Boran, Horro and their crosses with Friesian, Jersey and Simmental exotic sire breeds. The overall mean mortality rates were 8.0, 3.2, 9.7, 8.8, 3.2, 1.6, 1.9, 4.9 and 4.6% for age groups: birth to 90 days, 91 to 180 days, 181 days to 1 year, 1 to 2 years, 2 to 3 years, 3 to 4 years, 4 to 6 years, 6 to 8 years and 8 to 10 years, respectively. Overall mortality was markedly affected ($p<0.01$) by dam breed, sire breed, exotic blood level and birth year. But, sex of the animal and season of birth had no significant effect. Dam breed markedly ($p<0.05$ and 0.01) affected mortality rates in the age groups birth to 90 days, 181 days to 2 years and 8 to 10 years. Horro crosses had 1.7 (65.4%), 0.6 (35.3%) and 12.9 (67.9%) higher mortality rates in the age groups 91 to 180 days, 4 to 6 years and 8 to 10 years, than Boran crosses. Except for 91 to 180 days, the Boran crosses had higher mortality rates up to 4 years of age than the Horro crosses. The effect due to sire breed was only important from 181 days to 2 years of age. During this time, Simmental sired crosses had significantly higher mortality. Exotic genetic inheritance markedly ($p<0.01$ & 0.05) affected mortality. Locals (0% exotic inherited) had 17.85 (38.8%) higher mortality than the average of the crosses with 50 and 62.5% exotic blood. Among the crosses mortality increased with increasing exotic blood level. From birth to 10 years of age male animals had 7.8 (16.6%) higher mortality than females. Only from 3 to 4 years of age animals born during the dry season had markedly higher ($p<0.01$) mortality than those born during the wet season. Year of birth had a significant ($P<0.01$) effect during the first 2 years life of animals. From the antemortem and postmortem diagnoses, the main reasons for the high mortality were found to be emaciation, enteritis, pneumonia and diarrhoea. Based on this study, it is suggested that crossbreeding program should be accompanied by good management and better health care in order to be able to decrease mortality rates.

## Introduction

Cattle mortality in traditional pastoral systems in Africa is high, especially in young stock and during the dry season (Sharma and Jain, 1976). High mortality in young stock is a major cause of low productivity in many African livestock production systems. Mortality rates of 20 - 25% are commonly recorded for calves (ILCA, 1990).

In general, the rearing of young animals from birth until the age when they can make satisfactory use of forage or coarser feedstuffs is a major problem throughout the world. This problem is more acute in developing countries where exotic dairy breeds and crossbreeds are used for dairy purposes.

In developing countries, calf mortality rate between birth and 3 months of age has been estimated to between 20% and 60% (McDowell, 1972). Preweaning losses are influenced by season of birth which has an effect on the quality and quantity of feed available, the incidence of diseases and the level of parasite infestation, management and season of birth. On the other hand, the factors which commonly cause death after weaning are diseases and malnutrition (ILCA, 1972). In general, a mortality rate over 5% is considered to be too high (Alemu and Teshome, 1987). This paper evaluated the mortality rate of 1620 animals born at the Holetta Research Centre over a period of 22 years (1974 - 1995).

## Materials and Methods

*Location and Data*. Data collected from 1620 animals were used for this study. The data were collected at the Holetta Research Centre for the crossbreeding program conducted from 1974 to 1995. The Research Centre is located at an altitude of 2400 m above sea level, receives an annual rainfall of 1060 mm with maximum average temperature of 21.35°C. The study was based on animals that died between birth and 10 years of age. The breeds used in this study were Boran and Horro (dam breeds) their progenies of the crosses among Friesian, Jersey and Simmental exotic sire breeds.

### *Animal Management*

*Pre-weaning*. Over the years, two calf rearing systems were practised. Calves born between 1974 and 1977 were sucked their dams (local cows) twice per day up to weaning age (6 months). During this period calves were kept indoors and received roughage *ad lib*. and up to 2 kg of concentrate supplement per day. Calves born after 1977 were bucket fed and received 260 litres of whole milk over a period of 3 months, and were kept indoors and managed similarly to the above group up to 6 months of age.

*Post - weaning*: All groups of animals were put on natural pasture to graze for a period of 8 hrs per day. During the evening, calves were provided with grass hay and, when possible, with 1 kg of concentrate supplement up to the age of one year. Dry cows and heifers did not receive any concentrate supplement. Lactating cows received up to 4 kg of concentrate ration in two equal meals during morning and evening milkings. Male animals kept for breeding purposes received 1 kg of concentrate mixture per day. All animals were drenched and sprayed against internal and external parasites as parasite infestation occurred. The whole herd is vaccinated once a year against anthrax, contagious bovine pleuropneumonia and rinderpest, and twice a year against blackleg and pasteurellosis. However, animals were usually subjected to anthrax and blackleg after weaning when they were exposed to the external environment without being vaccinated. Currently weaned calves are

vaccinated against the above mentioned diseases before they are directly mixed with the other animals out in the field.

Mortality rate (%) was calculated by the following formula (Sharma and Jain, 1976).

$$\text{Mortality rate} = \frac{d_i}{b - (di-1)} \times 100$$

Where,

$d_i$ = number of animals died in the ith age group
$b$ = total number of calves born
$d_i - 1$ = number of deaths up to previous age group.

Mortality rates for the following age groups were calculated.

1. Birth-90 days
2. 91 to 180 days
3. 181 days to 1 year
4. 1 to 2 years
5. 2 to 3 years
6. 3 to 4 years
7. 4 to 6 years
8. 6 to 8 years
9. 8 to 10 years

Animals that were culled, sold or transferred to another Research Centre at different age groups were not taken into consideration. The effect of birth season, sex, breed, exotic blood level and birth year on mortality rate were calculated using the General Linear Model (GLM) of the Statistical Analysis System (1987).

## Results and Discussion

The analysis of variance and mean mortality rates (%) for different age groups as affected by dam breed, sire breed, exotic blood level, sex, season birth and year of birth are presented in Tables 1 and 2, respectively.

*Age group*

Generally, mortality rate increased up to 2 years of age then decreased to less than 2% and finally increased as the animals got older. This agrees with the report of Coppock (1994) who indicated that mortality rates for adult cattle (> 2 years) are low with an annual rate of about 5% and are due mostly to diseases and accident. Kale and Mandakmale (1993), on the contrary, reported a gradual reduction in mortality up to 24 months of age. Mortality rate was higher during the first 3 months of life. This could possibly be due to deficiencies in the calf immune system (Alemu and Teshome, 1987) Or adaptational (hygienic) stresses (Mengesha 1993). The over all mortality increased by 203% after weaning (180 days of age). In general, as one would expect, the mortality rate was high in the post-weaning compared to the pre-weaning period when animals were exposed to an environmentally more stressful and less nutritional conditions, suggesting that more care should be given during this period.

*Dam breed*

Dam breed significantly ($P < 0.01$ & $P < 0.05$) affected mortality rates in the age groups: birth to 90 days, 181 days to 2 years and 8 to 10 years of age (Table 1). But, the effect was not apparent for age groups 91 to 180 days and 2 to 8 years of age (Table 1). Except for 91 to 180 days, the Boran crosses had higher mortality rates up to 4 years of age than Horro crosses. Horro crosses had 1.7 (65.4%), 0.6 (35.3%) and 12.9 (67.9%) higher mortality rates in the age groups; 91 to 180 days, 4 to 6 years and 8 to 10 years, respectively than Boran crosses. Contrary to this result, Gebre-Egziabher *et al.* (1991) reported higher mortality for Horro crosses (72.24%) than Boran crosses (67.67%) up to 3 years of age.

*Sire breed*

Sire breed had marked ($P < 0.05$) effects on mortality only from 181 days to 2 years of age (Table 1). From birth to 90 days of age, locals had higher mortality than the crosses. Among sire breeds, Simmental had higher mortality in most age groups than the other sire breeds. Friesian crosses had lower mortality up to yearling and higher mortality from 1 to 3 years of age than Jersey crosses and then the mortality declined as they got older. Gebre-egziabher *et al.* (1990) reported that the mortality rate of Friesian and Jersey crosses up to 3 years of age were 65.4 and 73.7%, respectively. Jersey crosses were lighter up to one year of age than Friesian and Simmental crosses (Sendros *et al.*, 1987). Under indoor management (i.e. until weaning) mortality rates were higher in crosses of smaller exotic sire breeds than larger ones. When animals are kept indoor the climatic and nutritional stresses are generally low favouring larger breeds. However, under outdoor conditions the smaller breeds could tolerate the heat stress for they have higher surface area to volume ratio. In addition, smaller breeds have reduced nutrient requirements than larger ones so as they can sustain on the existing poor quality and quantity tropical pastures (Williamson and Payne, 1965). This might have attributed to the low pre-weaning and high post-weaning mortality of the larger than the smaller breeds.

*Exotic blood level*

Exotic blood level inheritance significantly ($P < 0.01$ & $P < 0.05$) affected mortality from 91 days to 8 years of age. The effect was not marked in the other age groups (Table 1) birth to 90 days of age. Except for birth to 90 days of age, crossbred calves with 75% exotic blood level had higher ($P < 0.05$ & $P < 0.01$) mortality up to 2 years of age than the rest. In most cases mortality rate increased as exotic blood level increased. Similar results have been obtained at Arsi (Olson *et al.*, 1986) and Holetta (Alemu and Teshome, 1987). Crossbreeding program, therefore, should be accompanied by good management practices to decrease mortality rates.

*sex*

The effect of sex on mortality was significant ($P < 0.01$) in the first 3 months of life and from 1 to 3 years of age (Table 1). Except for the age group 91 to 180 days, male animals had higher mortality up to 3 years of age. This result agrees with Gebre-Egziabher *et al.* (1991) who reported higher mortality in male than in female animals up to 3 years of age.

Table 1: Analysis of variance (mean square values and test of significance) for percent of mortality rates for different age groups

| source of variation | Birth to 90 days | 91 to 90 days | 181 days to 1 year | 1 to 2 years | 2 to 3 years | 3 to 4 years | 4 to 6 years | 6 to 8 years | 8 to10 years |
|---|---|---|---|---|---|---|---|---|---|
| Dam breed | 0.783 ** | 0.098 ns | 0.371 * | 0.452 * | 0.029 ns | 0.012 ns | 0.004 ns | 0.057 ns | 0.354 ** |
| Sire breed | 0.051 ns | 0.031 ns | 0.141 ** | 0.235 * | 0.055 ns | 0.040 ns | 0.015 ns | 0.010 ns | 0.029 ns |
| Exotic blood level | 0.096 ns | 0.134 * | 1.114 ** | 0.557 ** | 0.030 ns | 0.185 ** | 0.014 ns | 0.222 ** | 0.059 ns |
| Sex | 0.630 ** | 0.024 ns | 0.241 ns | 1.025 ** | 0.276 ** | - | - | - | - |
| Season of birth | 0.155 ns | 0.021 ns | 0.088 ns | 0.156 ns | 0.003 ns | 0.129 * | 0.008 ns | 0.009 ns | 0.130 ns |
| Year of Birth | 1.469 ** | 0.230 ** | 0.895** | 0.911 ** | 0.011ns | 0.026 ns | 0.011 ns | 0.050 ns | 0.010 ns |

Table 2. Mortality rate (% of deaths in relation to births), numbers in parenthesis are animals that died in each age group

| Source | Animals born | Birth to 90 days | 91 to 180 days | 181 to 1 year | 1 to 2 year | 2 to 3 year | 3 to 4 year | 4 to 6 year | 6 to 8 year | 8 to 10 year |
|---|---|---|---|---|---|---|---|---|---|---|
| Over all mean | 1620 | 8.0 (129) | 3.2 (47) | 9.7 (130) | 8.8 (78) | 3.2 (22) | 1.6 (8) | 1.9 (9) | 4.3 (18) | 4.6 (6) |
| Dam breed | | | | | | | | | | |
| Boran | 1111 | 9.4 | 2.6 | 10.9 | 10.4 | 3.7 | 3.5 | 1.7 | 5.8 | 1.9 |
| Horro | 509 | 4.7 | 4.3 | 7.3 | 5.7 | 2.3 | 2.4 | 2.3 | 3.1 | 14.8 |
| Sire breed | | | | | | | | | | |
| Friesian | 597 | 7.8 | 2.2 | 7.7 | 8.5 | 4.2 | 2.2 | 1.1 | 5.5 | 2.0 |
| Jersey | 472 | 8.2 | 3.5 | 10.5 | 5.8 | 1.0 | 5.7 | 3.1 | 5.0 | 7.5 |
| Simmental | 445 | 7.1 | 4.2 | 12.5 | 13.2 | 5.1 | 1.7 | 2.0 | 5.1 | 6.7 |
| Boran | 60 | 10 | 3.7 | 7.8 | 13.9 | 2.8 | 4.8 | 3.1 | 3.8 | - |
| Horro | 46 | 10.8 | 2.4 | 5.1 | - | - | - | - | - | - |
| Exotic blood level (%) | | | | | | | | | | |
| 0 | 106 | 10.4 | 3.1 | 6.7 | 7.6 | 1.4 | 2.8 | 1.6 | 2.1 | - |
| 50 | 968 | 7.6 | 2.1 | 7.5 | 6.8 | 2.9 | 1.8 | 1.6 | 3.3 | 6-2 |
| 62.5 | 206 | 11.6 | 3.9 | 9.5 | 9.4 | 7.3 | - | - | 6.7 | - |
| 75 | 340 | 5.8 | 5.6 | 17.3 | 15.4 | 3.9 | 9.3 | 3.8 | 8.5 | - |
| Sex | | | | | | | | | | |
| Female | 844 | 6.2 | 3.5 | 8.4 | 6.7 | 2.2 | - | - | - | - |
| Male | 776 | 9.9 | 2.7 | 11.4 | 13.7 | 6.7 | - | - | - | - |
| Birth Season | | | | | | | | | | |
| Dry | 1034 | 8.6 | 3.5 | 10.6 | 10.1 | 3.0 | 4.6 | 1.7 | 4.9 | 2.3 |
| Wet | 586 | 6.8 | 2.6 | 8.3 | 6.5 | 3.4 | 0.9 | 2.3 | 4.8 | 8.9 |
| Birth year | | | | | | | | | | |
| 1974 -1980 | 423 | 0.4 | 3.9 | 2.9 | 3.7 | 2.8 | 3.5 | 2.1 | 5.1 | 7.3 |
| 1981 -1985 | 417 | 6.9 | 2.3 | 9.9 | 17.2 | 3.6 | 1.6 | 1.4 | 2.9 | - |
| 1986 -1990 | 417 | 9.3 | 6.8 | 15.1 | 7.0 | 3.9 | 5.3 | 3.2 | 9.2 | - |
| 1991 -1995 | 363 | 16.2 | 2.7 | 12.5 | 6.4 | 2.5 | - | - | - | - |

*Season Birth*..With the exception of animals in 3 to 4 years age group, season of birth had no effect on mortality rate of local and crossbred cattle. Though not significant, calves born during the dry season had higher mortality. This might be attributed to shortage of feed in terms of both quality and quantity during the dry season.

*Year of Birth*. The effect due to year of birth was highly significant ($p<0.01$) up to the age of 2 years. For all age groups from birth to 1 year of age, mortality was lower during the first half of the study period. The differences associated with year of birth on mortality rates might be due to annual changes in environmental conditions, variation in the quantity and quality of feed, disease prevalence and differences in management practices followed over the years. Antemortem and postmortem diagnoses revealed that the reasons for death and the percentage contribution of each to the total mortality (Table 3). Emaciation, enteritis, pneumonia and diarrhoea were the main causes for higher mortality. Emaciation could be due to malnutrition, old age, internal parasites and loss of appetite. Morality increased with increased exotic blood level. The results from this study showed that crossbreeding program should be accompanied by good management. The higher mortality recorded during post-weaning when animals were exposed to an environmentally more stressful and less nutritional conditions also indicate that more care should be given during this time. Besides, since most of the deaths occurred due to infectious deceases and other health disorders better herd health care should be an integral part of the program to reduce mortality.

Table 3. Reason for mortality and percentage distribution

| Reason | Number died | % contribution |
|---|---|---|
| Emaciation | 91 | 20.4 |
| Enteritis | 73 | 16.3 |
| Pneumonia | 69 | 15.6 |
| Diarrhoea | 55 | 12.3 |
| Heart water | 29 | 6.4 |
| Mechanical injury | 27 | 6.1 |
| Anthrax | 24 | 5.3 |
| Black leg | 19 | 4.3 |
| Bloating | 10 | 2.3 |
| Poisoning | 10 | 2.2 |
| Traumatic pericarditis | 10 | 2.3 |
| Rabies | 8 | 1.7 |
| Tetanus | 3 | 0.7 |
| Others* | 19 | 4.3 |
| Total | 447 | 100.00 |

*These include skin disease, paralysis, nervous problem, abortion complication, hypocalcemia (milk fever), babesiosis.

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# Bioassay of Acaricide Resistance on Three Common Cattle Tick Species Around Holetta Area

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## Abstract

Bioassay of acaricide reseistance on three common cattle tick species was conducted at the Institute of Agricultural Research, Holetta Research Centre by using standardized FAO Acaricide Resistance Test Methods. Larval progeny of *Boophilus decoloratus, Rhipicephalus evertsi evertsi* and *Amblyomma varigatum* were subjected to larval packet test (LPT) employing four different acaricides namely, Dieldrin, Diazinon, Chlorfenvinphos and Coumaphos, each with five concentration levels. Statistical assessment of pooled mortality rates (least square means ± standard error) to the tested acaricides were 67.93 ± 0.86 for B.decoloratus, 97.93 ± 0.86 for R. e.evertsi and 97.23 ± 0.86 for *A. varigatum*. These values were different ($P < 0.001$) between *B. decoloratus* on the one hand and R. e.evertsi and *A. varigatum* on the other hand. However, there was no difference ($P > 0.05$) between R. e. evertsi and *A. varigatum*. The efficacy of Dieldrin, Diazinon, Chlorfenvinphos and Coumaphos against all test ticks were 74.27 ± 0.99, 84.72 ± 0.99, 96.82 ± 0.99 and 94.98 ± 0.99, respectively. Dieldrin and Diazinon and Diazinon had higher ($P < 0.001$) killing rates of test ticks than Chlorfenvinphos and Coumaphos. The finding of organophosphate (Diazinon) resistance is the first report of its kind in the country. It is generally presumed that resistant tick population is emerging at an increasing pace in the area warranting a serious attention. The poor efficacy of Dieldrin and Diazinon may be attributed to the extensive use of chemicals like BHC & Bacdip. Furthermore, their faulty application characterized by irregular sprayin, failure to maintain adequate lethal concentrations, reliance on one component of tick control strategy and other managerial constraints could have contributed to the developed resistance problems. It is therefore, high time to revise and consider the existing or other tick control strategies that could best address the alarming resistance problem as well as the managerial constraints hampering the successful use of acaricides.

Introduction

Ticks are considered as the most damaging livestock pests on a global scale. Approximately 80% of the world's cattle population are at risk visavis tick infestation and tick-borne diseases (Pegram et al., 1993). Ticks are responsible for a great diversity of livestock health problems. Their infestation alone can give rise to severe irritation and trauma which results in substantial economic losses from reduced milk yield, skin and hide damage, and responsible for the transmission of protozol, rickettsial, bacterial and viral diseases among domestic animals (Keating, 1983).

According to McCosker (1979), it is estimated that the global costs of tick control and productivity losses account for 7000 million USD annually. Comparative date on the economic losses from icks in African livestock are lacking, however, an estimated 168 million USD in eastern, central and southern Africa is only caused by East Cost Fever (ECF) (Dipeolu et al. 1992). The impact from such losses are exacerbated in tropical and subtropical environments where the hosts are subjected to additional stresses associated with sub-optimal nutrition and high environmental temperature.

In Ethiopia, an annual estimated loss of 1 million Birr is attributed to the down grading of hides and skins due to tick infestation (Feseha, 1983). With the inclusion of losses from reduced productivity and deaths and costs of tick control, the estimated total loss is definitely much more greater than this.

Over the past many decades the conventional means of tick control is the application of acaricides in dips and sprays. This method has resulted in a profound influence on livestock productivity through dramatic reduction in the prevalence of tick infestation and associated tick-born diseases. Acaricides, particularly the stable and persistent ones, have provided a rapid and efficient means of combating livestock ticks in many parts of the world (Tatchell, 1983). This method has also been practised in several parts of Ethiopia and seems to remain a dependable weapon for the foreseeable future (Regassa and De Castro, 1993). However, their injudicious use represents the greatest threat to libestock industry of many countries. Over reliance and misuse of most chemical acaricides have resulted in rapid emergence of resistant tick populations and objectionable pesticide residues in the environment.

The first tick resistance outbreak was reported from Australia by the cattle tick Boophilus microplas to arsenic compounds and subsequently from south Africa and Latin America. Resistance to this chemical did not appear until after several decades of use, but resistance to chlorinated hydrocarbons appeared with far greater rapidity and is now complicated by cross-resistance between various compounds of the group (Nolan and Roulston, 1997). Possibly, because of its one host behaviour and its prolonged exponsure to treaments, the genus Boophilus has shown the greatest tendency to develop resistance (Duncan, 1993).

As far as the Ethiopian condition is concerned, unconfirmed reports from all corners of the country strongly suggest presence and increasing problems associated

with tick-acaricide resistance. The situation is further compounded by the absence of an effective legislation for importation, marketing and monitoring of acaricide use, a fact that considerably contributed to their indiscriminate uses all over the nation. Information in this regard is therefore, of paramount importance in deciding on the choice of appropriate tick and tick-borne disease control strategies in different localities in the country.

This paper reports the presence of acaricide resistance on three common cattle tick species and characterise the nature and spectrum of anticipated acaricide resistance so as to recommend a feasible tick control scheme applicable in the central highlands of Ethiopia.

## Materials and methods

The study was conducted in the Holetta area, central highlands of Ethiopia (38° 3' E and 9° 3' N) both on-farm and at the Holetta Research Centre (HRC) of the Institute of Agricultural Research (IAR). The area receives an annual rainfall of about 1200 mm, has an altitude of 2400 m a.s.l. and temperature range of 20°C to 27°C (maximum) and 2°C to 9°C (minimum).

Farming is generally dominated by smallholder crop-livestock mixed system in which cattle husbandry mainly stands for milk production and traction. The predominant cattle breeds are zebu with some European crosses. Animals are usually grazed during day time and supplemented with crop residues and hay in the evenings.

Three sites in the vicinity of the research centre and the centre herds are considered in this study. The nature and the type of the acaricide applied in the selected farm area are summarised in Table 1.

Table 1. Description of study farms: acaricide and their applications as exercised during the past few years.

| Study Sites | Acaricide | Method of application |
|---|---|---|
| Jerba - Sefer | BHC, Asuntol, Bacdip, Supona | Hand spray |
| Chiri | BHC, Asuntol, Bacdip, Supona | Hand spray |
| Sademo | BHC, Asuntol, Bacdip, Supona | Hand spray |
| HRC | Asuntol, Bacdip, Supona | Spray race & Hand spray |

Over the past many years, Hexachlorohexane or commonly known as BHC was the most widely used acaricide for the control of ticks in the area and now it is supplemented with chemicals of organophosphate group bacdip, chlorofenvinphos and coumaphos. Except for the research centre, acaricides are applied irregularly when engorged adult ticks are apparent on cattle.

## Tick collection and breeding

Fully engorged females of three species of ticks, namely *Boophilus decoloratus*, *Rhipicephalus evertsi evertsi* and *Amblyomma varigatum* were collected and identified employing standard keys set by Morel (1980). Following identification, five females of each tick species were placed in a separate glass tube and incubated at temperature of 27 ± 1°c and relative humidity of 85% to 90% for oviposition as per standard procedures recommended by FAO (1984).

## The test method

FAO-Acaricide resistant test kit containing paper impregnated with four different acaricide, namely Dieldrin, Diazinon, Chlorfenvinophos, and Coumaphos in equal number of different concentrations was obtained from FAO-World Acaricide Resistance Reference Centre (WARRC), Berlin, Germany (Table 2).

Table 2. Types of acaricide and the respective concentration levels contained in the FAO-Acaricide Resistance Test Kit.

| | IXODICIDES | | | |
|---|---|---|---|---|
| Concentration | Dieldrin* | Diazinon† | Chlorfenvinophos | Coumaphos |
| 1 | 0.1 | 0.0125 | 0.0125 | 0.00625 |
| 2 | 0.2 | 0.025 | 0.025 | 0.0125 |
| 3 | 0.4 | 0.05 | 0.05 | 0.025 |
| 4 | 0.8 | 0.1 | 0.1 | 0.05 |
| 5 | 1.6 | 0.2 | 0.2 | 0.1 |

* Dieldrin is a reliable Toxaphene and Lindane (BHC) resistance indicator.
† Diazinon is considered as a general indicator of Organophosphate resistance

The test was employed based on the larval packet test described by stone and Hydock (1962) which allows to asses the presence of acaricide resistance. The procedure was applied to all larvae from the three species and repeated over several times according to the number of samples and sampling frequency.

## Reference strains

Reference tick strains of *Boophilus decoloratus* and *Rhipicephlus e. evertsi* were collected from Wollenchity (East Shoa) area where previous history of acaricide usage was minimum. Larvae of each reference ticks were subjected to resistance tests against four acaricides in order to obtain data base on susceptible tick population so as to allow

tangible comparison with those of the anticipated resistant population from the study area.

*Statistical procedure*

General Linear Model of SAS (1987) was used to calculate effects of different factors. Least squares means and standard error were calculated for test ticks mortality and efficacy of acaricide used in this study.

## Result and Discussion

### The reference strains

Both, *B. decoloratus* and *R.e. evertsi* used as reference strain showed the highest mortality rates to different concentrations of accarcide used. The mean percentage mortality *of B. decoloratus* to dieldrin was 99.7%, Diazinon 99%, Chlorfenvinphos 100% to Coumaphos.

*Test ticks*

*Boophilus decoloratus*

The poold mortality rate (LS mean ± se) for B.decoloratus exposed to the tested acaricide was 67.93 ± 0.86. This value showed hgihly significant difference ($P<0.001$) to *R.e.evertsi* and *A.varigatum*. At 1.6 concentration of Dieldrin, the least mortality rate was recorded at Jerba-sefer (20.5%) and the highest the Holetta Research Center (61%) (Table 3). The pooled mortality rate for *B. decoloratus* to Dieldrin for all study sites was 27.71±1.71 (Table 5). The poor efficacy of this chemical may be associated with prolonged application of BHC and failure to maintain adequate concentration. However, an apparently higher larval mortality observed at HRC is probably due to the recent shift made from the use of organochlorine to organophosphate and to the method of acaricide application, spray race, a technique relatively less affected by manipulators. On the other hand, at the highest concentration (0.2) of Diazinon the least mortality recorded was obtained at HRC (55.2%) and the highest at Sademo (91.1%) (Table 3). The pooled mortality rate for *B. decoloratus* to Diazinon for all study sites was 54.99 ± 1.72 (Table 5). Like that of Dieldrin the efficacy of Diazinon against *B. decoloratus* was poor and had highly significant variation ($P<0.001$) to Chlorfenvinphos and Coumaphos. Whereas the results of bioassay trial with Chlorfenvinphos and Coumaphos on *B. decoloratus* revealed mortality ratesof 94.31 ± 1.72 and 94.70 ± 1.72, respectively (Table 5). There was no significant difference

($P > 0.05$) between the two chemicals. The results in the present study agree with the findings of other authors (Teshome and Feseha, 1987; Regassa and De Castro, 1993) who reported that most of *B. decoloratus* in western Ethiopia were resistant to the organochlorine compound, Toxaphene. Resistance to chlorinated hydrocarbons is usually complicated by cross resistance between various compounds of the group. Fledier (1952) and Whitnall *et al.* (1952) demonstrated that BHC resistant strains of *B. decoloratus* in South Africa were also resistant to Toxaphene. It is therefore most likely that *B. decolorartus* studied in this area may also be resistant to Toxaphene. Resistance of *B. decoloratus* to organophospherus has been recorded in South Africa (Shaw *et al.*, 1967) and Zambia (Mathewson and Blackman, 1980). Results of this study also agree with the above workers regarding the low level of Diazinon resistant population of *B. decoloratus*. This could probably be due to utilization of bacdip (oranophospherus) for along period of time and its eventual replacement by other related organophospherus compounds. The limited information available suggest that there is no report of what so ever on organophospherus resistance in Ethiopia.

***Rhipisephalus evertsi evertsi***

*R.e. evertsi* larvae from HRC, Sadamo and Jerba-sefer revealed 100% mortality to Dieldrin with concentrations exceeding 0.1, 0.2 and 1.6, respectively. The list percentage mortality with the lowest concentration (0.1) was found at Chiri (80.44%) (Table 3). The pooled mortality rate of *R.e.evertsi* to all tested acaricides was 97.93 ± 0.86, which was not different ($P > 0.05$) to *A. varigatum*, but highly significantly different ($P < 0.001$) *to B. decoloratus* the mortality rate of *R.e.evertsi* to Dieldrin for all study sites was 96.27 ± 1.72 (Table 5). This value was different ($P < 0.01$) to *B.decoloratus* exposed to Dieldrin and Diazinon but did not differ ($P > 0.05$) with *B. decoloratus* exposed to Chlorpenvinphos and Coumaphos and *A. varigatum* exposed to all test acaricides. On the other hand, the percentage mortality shown by *R.e.evertsi* to Diazinon varied between 98 and 100 % complete mortality was recorded on samples obtained from HRC and Sadamo with minimum (0.012) concentration of Diazinon (Table 3). Similarly the mortality rate *of R. e. evertsi* to Diazinon for all study sites was 99.77 ± 1.72 (Table 5). This value was highly different ($P < 0.001$) from *B. decoloratus* exposed to Dieldrin and Diazinon and to *B. decoloratus* exposed ($P < 0.05$) to Chlorfenvinphos and Coumaphos, but had no difference ($P > 0.05$) to *A. varigatum* exposed to all test acaricides. At the concentration levels of 0.0125, 0.025, 0.05 and 0.1 the mortality of *R. e. evertsi* larvae to Chlorfenvinphos was 100% for HRC, Jerba-sefer, Sadamo and Chiri, respectively. On the other hand, 100 % larval mortality occurred to Coumaphos at concentration levels exceeding 0.0125, 0.02 and 0.05 for Jerba-sefer and Sadamo, Chiri and HRC, respectively. The mortality rate of *R. e. evertsi* to Chlorfenvinphos and Coumphos for all study sites were 98.51 ± 1.72 and 97.19 ± 1.72, respectively (Table 5). These values had highly significant difference ($P < 0.001$) to *B. decoloratus* exposed to Dieldrin and Diazinon, but had no significant difference ($P < 0.05$) to *B. decoloratus* exposed to Chlorfenvinphos and Coumaphos and

to *A. varigatum* exposed to all test chemicals. Though previous works of Teshome and Feseha (1987) at Bako area, and Regassa and De Castro (1993) in western Ethiopia indicated the existence of low level of resistance of *R. e. evertsi* to organochlorine compounds, in this study, *R. e. evertsi* was found to be highly susceptible to all acaricides used. This tick species was also found to be resistance to Toxaphene and BHC in several other African countries, particularly eastern Africa where control of theleriosis necessitated an intensive application of this chemical (Wherton, 1976; Chema, 1984).

*Amblyoma varigatum*

In this study, *A. varigatum* was also found to be highly susceptible to Dieldrin as well as the rest of organophosphates, the pooled mortality rate of *A. varigatum* to ali tested acaricides was 97.23 ± 0.86. This had no significance difference ($P<0.05$) to *R. e. evertsi* exposed to all tested acaricides. With the list concentration of Dieldrin 100% mortality was recorded at HRC and with concentrations exceeding 0.4 for the rest (Table 3). The mortality rate of *A. varigatum* to Dieldrin, Diazinon, Chlorfenvinphos and Coumaphos was 98.3 ± 1.72, 99.40 ± 1.72, 97.64 ± 1.72, and 93.06 ± 1.72, respectively (Table 5). These values were highly significantly different ($P<0.001$) to *B. decoloratus* exposed to Dieldrin and Diazinon, but had no significant difference ($P>0.05$) to *B. decoloratus* exposed to Chlorfenvinphos and Coumaphos and *R. e. evertsi* exposed to all tested acaricides. Unlike this work, varying degrees of resistance to Toxaphene and BHC were documented in sporadic sites in Zambia and Tanzania (Wharton, 1976). To our knowledge there are not published reports regarding the occurrence of acaricide resistant *A. varigatum* in Ethiopia.

Generally the efficacy of Dieldrin, Diazinon, Chlorpenvinphos and Coumaphos against all test ticks for all study sites were 74.27 ± 0.99, 84.27 ± 0.99, 86.82 ± 0.99 and 94.98 ± 0.99, respectively. Dieldrin and Diazinon had highly significant difference ($P<0.001$) to Chlorphnvinphos and Coumaphos in killing the test ticks. But there was no significant difference ($P>0.05$) between Chlorfenvinphos and Coumaphos.

In attempt to study the emergence of resistance to acaricide, numerous predisposing factors must be considered. Poor pesticide management procedures, inefficient application of acaricide and faulty mixing of chemicals are some of the management problems observed during this study which might have resulted in exposure of ticks to sub-lethal concentrations of acaricides.

Table 3. Pooled percentage mortality rate of *B. decoloratus*, *R. e. evertsi* and *A. varigatum* test ticks exposed to different concentrations of Dieldrin and Diazinon supplied by FAO-WARRC, Berlin, Germany.

| | | Dieldrin concentration | | | | | Diazinon concentration | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0.1 | 0.2 | 0.4 | 0.8 | 1.6 | 0.0125 | 0.025 | 0.05 | 0.1 | 0.2 |
| Study sites | Tick species | Pooled larval mortality | | | | | Pooled larval mortality | | | | |
| Jerba-sefer | B. decoloratus | 10.5 | 15.0 | 17.2 | 17.9 | 20.5 | 28.1 | 29.9 | 40.6 | 77.5 | 90.2 |
| | R. e. evertsi | 81.9 | 92.4 | 98.0 | 99.0 | 100 | 98.0 | 99.7 | 100 | 100 | 100 |
| | A. varigatu | 98.1 | 99.1 | 100 | 100 | 100 | 98.0 | 100 | 100 | 100 | 100 |
| Chiri | B. decoloratus | 15.1 | 20.6 | 22.0 | 32.2 | 45.7 | 25.9 | 43.7 | 50.5 | 64.5 | 87.7 |
| | R. e. evertsi | 80.4 | 86.7 | 92.9 | 99.1 | 99.8 | 98.7 | 99.1 | 100 | 100 | 100 |
| | A. varigatu | 93.6 | 99.0 | 100 | 100 | 100 | 98.6 | 99.1 | 99.5 | 100 | 100 |
| Sadamo | B. decoloratus | 12.1 | 20.3 | 22.7 | 29.4 | 30.2 | 50.0 | 62.6 | 82.5 | 90.2 | 91.1 |
| | R. e. evertsi | 95.4 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| | A. varigatu | 89.2 | 97.6 | 100 | 100 | 100 | 96.2 | 100 | 100 | 100 | 100 |
| HRC | B. decoloratus | 21.0 | 30.8 | 54.1 | 55.3 | 61.9 | 12.5 | 30.1 | 38.0 | 49.5 | 55.2 |
| | R. e. evertsi | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| | A. varigatu | 100 | 100 | 100 | 100 | 100 | 96.7 | 99.9 | 100 | 100 | 100 |

Table 4. Pooled percentage mortality rate of *B. decoloratus*, *R. e. evertsi* and *A. varigatum* test ticks exposed to different concentrations of Chlorfenvinphos and Coumaphos supplied by FAO-WARRC, Berlin, Germany

| | | Chlorfevinphos concentration | | | | | Coumaphos concentration | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0.0125 | 0.025 | 0.05 | 0.1 | 0.2 | 0.00625 | 0.0125 | 0.025 | 0.05 | 0.1 |
| Study sites | Tick species | Pooled larval mortality | | | | | Pooled larval mortality | | | | |
| Jerba-sefer | B. decoloratus | 87.1 | 92.3 | 100 | 100 | 100 | 86.6 | 95.0 | 95.0 | 100 | 100 |
| | R. e. evertsi | 98.0 | 100 | 100 | 100 | 100 | 99.7 | 100 | 100 | 100 | 100 |
| | A. varigatu | 89.7 | 95.6 | 100 | 100 | 100 | 86.0 | 92.5 | 92.5 | 95.7 | 99.0 |
| Chiri | B. decoloratus | 95.5 | 98.5 | 100 | 100 | 100 | 95.2 | 100 | 100 | 100 | 100 |
| | R. e. evertsi | 92.5 | 96.0 | 99.1 | 100 | 100 | 91.2 | 100 | 100 | 100 | 100 |
| | A. varigatu | 100 | 100 | 100 | 100 | 100 | 80.5 | 95.7 | 95.7 | 100 | 100 |
| Sadamo | B. decoloratus | 69.0 | 81.6 | 85.4 | 91.2 | 99.5 | 69.0 | 85.4 | 85.4 | 100 | 100 |
| | R. e. evertsi | 87.9 | 96.7 | 100 | 100 | 100 | 96.7 | 100 | 100 | 100 | 100 |
| | A. varigatu | 82.7 | 89.5 | 96.7 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| HRC | B. decoloratus | 87.5 | 98.7 | 100 | 100 | 100 | 87.5 | 100 | 100 | 100 | 100 |
| | R. e. evertsi | 100 | 100 | 100 | 100 | 100 | 76.7 | 98.7 | 98.7 | 100 | 100 |
| | A. varigatu | 99.5 | 99.2 | 100 | 100 | 100 | 76.5 | 85.5 | 85.5 | 89.6 | 96.7 |

It is therefore, high time to revise and consider the existing or other tick control strategies that could best address the alarming resistance problem as well as the managerial constraints hampering the successful use of acaracides. Moreover, problems posed by ticks and their diversified interactions with the ecosystem are also too dynamic to be solved by reliance on one component of control systems. It is therefore, necessary to develop a sustainable and integrated tick control schmes in which the isolated method may be individually inadequate but together with other may exert a vigorous synergy. On the basis of the findings from the present study other findings, the following recommendations are formulated.

1. Development and application of an integrated tick control management is an indispensable approach. This method consist of use of tick resistant cattle breeds, pasture management, a habitat modification and immunization in combination with the rational use of acaricides. Even though, the prospects for this approach is far beyond the realm of fact at least in the near future in developing countries like Ethiopia. It is an area of considerable value as it is the most sustainable method and keeps enzootic stability undisturbed.
2. In places where alternative chemicals are not available, restoration of a satisfactory level of efficacy of chemicals affected by resistance mechanisms through synergism and increasing concentrations are effective tactics in dealing with the low level of resistance.
3. Appropriate and rational use of any new acarcide should be encouraged through training and extension. To this end, it is recommended that appropriate polices should be set for importation, assessment of efficacy and monitoring of their eventually use in the field.
4. Quarantine measures should be drown to reduce the possibility of introduction of ticks and tick-born diseases with imported exotic cattle.
5. Survey on resistance of acaricide should be carried out in different parts of the country.

Table 5. Pooled mortality rate (least squares means± standard error) of B. decoloratus, R. e. evertsi and A. varigatum to Dieldrin, Diazinon, Chlorfenvinphos and Coumaphos for all study sites.

| | Pooled mortality rates of tick species | | |
|---|---|---|---|
| | *B. decoloratus* | *R.e.evertsi* | *A. varigatum* |
| Dieldrin | 27.71 ± 1.72 | 96.27 ± 1.72 | 98.83 ± 1.72 |
| Diazinon | 54.99 ± 1.72 | 99.77 ± 1.71 | 99.40 ± 1.72 |
| Chlorfenvinphos | 94.31 ± 1.72 | 98.51 ± 1.72 | 97.64 ± 1.72 |
| Coumaphos | 94.70 ± 1.72 | 97.19 ± 1.72 | 93.06 ± 1.72 |

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# A Study on Calf Mortality at Adamitulu Livestock Research Center

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## Abstract

The mortality rate of calves born from 1990 to 1992 at Adamitulu Livestock Rearch Center was studied within their first 6 months of age. The animals were crosses of Friesian, Simmental and Jersey sire breeds with Barka and Boran local dam breeds. Out of 194 live born calves, 34 (17.5 %) died within 6 months of life. The effects of exotic blood level, sex and age on mortality were not significant. Year and season variations had significant effect on calf mortality. High mortality rates were observed from July to September (rainy season) and November to January (dry season). Inadequate colostrum intake, pneumonia and scours were the principal causes of death. The pathogenic organisms identified from samples taken from pneumonic, scouring and febrile calves were: *Corynebacterium pyogenes, Pasteurella hemolytica, Escherichia coli, coccidia and Cowdria ruminantum.*

## Introduction

The term calf refers to a young bovine species up to six months of age (Jung, 1982). Calves have immunological incompetence and special sensitivities to handling and disease. They are highly susceptible to infectious diseases, dehydration and death. Well-bred and well reared calves are assured assets for future production and increased productivity, while mortality of calves entails loss of future production. High levels of calf mortality represent a significant barrier to the efficiency and productivity of dairy and beef farming.

In Ethiopia, as in most parts of the tropics, replacement heifers have to be reared. Therefore, the rate of calf losses determines the success of any dairy and beef enterprise. High death rate leads to shortage in replacement stock and therefore, uneconomic cows may have to be kept in the herd longer than they deserve. A calf mortality rate of 20% can reduce net profit by 38% (Blood *et al.*, 1989). Therefore, every practical economic effort should be made to minimize diseases and mortality. The mortality cost includes not only the value of the dead calf, but also the cost of food and treatment before its death. In typical individually owned sedentary herds of Ethiopia, calf mortality ranges from 30 to 40%. In well managed dairy herds, calf mortality does not usually exceed 5%, which can be tolerated by the farming community at present levels of labor and capital input (Roy, 1982). Although there have been some studies on the incidence and cause of calf mortality in countries with livestock farming practices similar to Ethiopia, research in this country has been very limited.

## Materials and Methods

The health performance of all calves born at the Adamitulu Research Center (where the calf management practices are above the national average) was studied during their first six months of life. The calves that died due to any cause had systematic post-mortem examination. Relevant samples were collected from the carcass for further investigation at the Center's mini laboratory. Management practices operating in the farm were observed, with special attention being given to colostrum intake, clemency of weather, feed supply, maternalism of dam and all other factors that could influence the survival rate. Data was statistically analyzed by General Linear Model (GLM) procedure using SAS (1987) to determine effect of breed, exotic blood level, season, year and sex on mortality of calves. Where differences existed between treatment means, the student t-test was employed to separate them.

## Results and discussion

Out of the 194 live born caves, 34 (17.5 %) died within 6 months of age. Breed variation on the mortality rate of calves was not significant. This is in conformity with the findings of Gebreigziabher *et al.* (1991). However, fewer number of Jersey cross calves died than Friesian and Simmental crossbred calves (Table 1). Year variation was significant ($p < 0.05$). The lowest calf mortality was registered in 1992. This was due to the strict management and health care measure taken during the year to reduce calf losses. In the Center's breeding scheme exotic blood level varies from 25% to 75% . In this study, however, effect of blood level on mortality was not significant (Table 2). Age and sex variation were not also significant (Table 3). The effects of season is shown in Table 4. Season variation had a significant ($p<0.01$) effect on calf mortality. High mortality rates were observed from July to September (rainy season) and from November to January (dry season). This may be attributed to the wet and cold conditions that could induce increased susceptibility to various calf diseases. Inadequate colostrum intake, pneumonia and scours were the principal causes of death (Table 5). Out of the colostrum deficient calves 4 died of scour, 2 of pneumonia and 3 without clear clinical symptoms. About 40% of the calves in the Center were born at night. Calves born at night wereassumed to have sucked and were removed from the dam the following morning and were not given colostrum until the afternoon. As a result the calf might absorb very little immunoglobulin. Closure to absorption of all immunoglobulin classes from the small intestine occurs about 24 hours after birth if a calf is not fed (3). The new born calf depends on antibodies it acquires from its dam via colostrum. Inadequate colostrum ingestion, therefore, predisposes the new born calf to infections. Foot and mouth disease (FMD) outbreak in the Center killed 2 calves in 1990.

Result of laboratory findings in samples taken from dead calves are shown in Table 6. Due to absence of adequate laboratory facilities, strains of bacteria and viral agents (serology) couldn't be identified. Existence of rota virus and bovine enteric corona virus were reported by Gopilo *et al.* (1991) in diarrhoeic calves of central Ethiopia. Concurrent or independent viral infections as a cause of diarrhea or pneumonia in the calves was a possible condition.

The rate of calf losses in this study (17.5%) was high in comparison with the

tolerable and economic death rate of 5% . Losses could be reduced through strict adherence to proper management practices, especially disinfection of navel at birth, cleaning of maternity pens, protection against draft and dampness, early ingestion of colostrum and early detection of sick animals. Therefore, appropriate measures should be taken to reduce calf deaths and improve the growth rate of the Center's stock.

Table 1. Effects of sire, dam and year on calf mortality.

| Effects | Mortality (% ± s.e) |
|---|---|
| Sire breed | |
| Boran | 9.6 ± 6.7 |
| Friesian | 17.1 ± 4.4 |
| Jersey | 6.0 ± 4.4 |
| Simmental | 20.0 ± 4.9 |
| P | ns |
| Dam Breed | |
| Boran | 18.0 ± 4.2 |
| Barka | 8.3 ± 3.1 |
| P | ns |
| Year | |
| 1990 | 10.5 ± 4.1 |
| 1991 | 23.9 ± 4.1 |
| 1992 | 5.0 ± 5.7 |

In this and subsequent tables ns=non significant at $P>0.05$;
*=significant at $P<0.05$; ** = significant at $P<0.01$.

Table 2. Effect of exotic blood level on calf mortality

| Parameters | Morality (%) |
|---|---|
| Blood level | |
| $F^1$ | 4.7 ± 16.3 |
| $F^3$ | 26.1 ± 8.9 |
| $F^4$ | 28.9 ± 8.9 |
| 25%E* | 3.0 ± 1.3 |
| 56.25%E | 6.7 ± 1.3 |
| 62.5%E | 15.9 ± 8.9 |
| 68.75%E | 14.2 ± 8.9 |
| 75%E | 4.0 ± 1.4 |
| P | ns |

$F^1$ = Local x Exotic; $F^3 = F^2 \times F^2$; $F4 = F^3 \times F^3$
*E=Exotic breed inheritance

Table 3. Effects of age and sex on calf morality

| Age (weeks) | Sex | | |
|---|---|---|---|
| | Male | Female | Mean |
| 0-1 | 3.1 ± 1.2 | 4.5 ± 1.2 | 3.8 ± 0.9 |
| 0-4 | 3.7 ± 1.2 | 4.3 ± 1.2 | 4.0 ± 0.9 |
| 4-8 | 6.2 ± 1.2 | 1.7 ± 1.2 | 3.9 ± 0.9 |
| 8-24 | 3.7 ± 1.2 | 5.3 ± 1.2 | 4.5 ± 0.9 |
| Mean | 4.2 ± 0.6 | 4.0 ± 0.6 | |
| P | | ns | |

Table 4. Calf mortality as affected by season

| Season | Mortality (%) |
|---|---|
| Dry | 5.0 ± 0.5 |
| Intemidate | 2.3 ± 0.6 |
| Rainy | 3.9 ± 0.5 |
| P | ** |

Table 5. Major causes for death of calves

| Causes | Number of deaths | | | | Overall death (%) |
|---|---|---|---|---|---|
| | 1990 | 1991 | 1992 | Total | |
| Inadequate Colostrum | 3 | 6 | - | 9 | 26.5 |
| Pneumonia | 4 | 3 | 1 | 8 | 23.5 |
| Scours | 2 | 4 | - | 6 | 17.7 |
| Navil ill | 1 | 2 | - | 3 | 8.8 |
| Mechanical injury | 1 | 1 | - | 2 | 5.9 |
| Foot and Mouth Disease | 2 | - | - | 2 | 5.9 |
| Cowdriosis | - | - | 1 | 1 | 2.9 |
| Unknown | 1 | 2 | - | 3 | 3.8 |
| Total | 14 | 18 | 2 | 34 | |

Table 6. Pahtogenic organisms identified

| Disease | Pathogen | Number of samples |
|---|---|---|
| Pneumonia | P.h, C.p | 5 |
| Scours | E.Coli, Coccidia | 6 |
| Navel ill | C.p | 3 |
| Heart water | C.r | 1 |
| Total | | 15 |

P.h = Pasteurella hemolytica
C.p = Corynebacterium pyogenes
E.Coli = Escherichia coli
C.r = Cowdria ruminantum

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# ANIMAL NUTRITION AND FEED RESOURCES

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# The Nutrition of Ruminant Animals in The Thermal Environment: Conditions and Prospects in Ethiopia

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## Abstract

The daily body heat production of a local steer with body weight of 300kg gaining at the rate of 200g/day and performing the regular activities for graying is calculated to be as high as 49.2MJ. Despite this, homeothermy is sustained because the heat produced is continuously lost to the environment. In the range of environmental temperatures representing the thermoneutral zone the thermal balance is maintained without the interference of conditions that impose negative impact on production. The thermoneutral zones for most ruminant livestock lie between 20°c and 30°c;for high milk producing dairy cows the upper critical temperature can be as low as 20°c. The mean annual temperature in Ethiopia does not exceed 25°c. But in some localities the day temperature in the dry season is more than 30°c which is higher than the upper critical temperature for ruminants. In such environmental conditions, the regulatory mechanisms of the body might not be adequate to dissipate the extra load of heat. As a result the animal will be forced to decrease heat production through the reduction of food intake and body activities. High ambient temperature is associated with drought and imposes in additional indirect negative impact on animal production by reducing the availability and quality of forages. It may then be essential to consider the use of multipurpose trees for the formation of favorable micro-climate and as a source of good feed at the time when this is critically short.

## Introduction

The production performance of livestock is a function of its genetics and environment. Among the many types of environmental factors, feeds impose the major influence on the productivity of farm animals. In Ethiopia, its quantity and quality are the technical characters which have been receiving some attention (Tefera, 1993). But, the voluntary intake of available feeds and the conversion of their nutrients into sellable or consumable animal products can also be governed by the direct effect of the thermal environment (Rock and Thomas, 1983).

The impact of temperature and solar radiation on the primary and secondary productivity in the tropics is pronounced by the effects of deforestation (Legel,1988). Improvement in production and productivity can be achieved with proper consideration of the ecological context of that system. The purpose of this paper is therefore to review the impact of the thermal environment on the interaction of nutrition and livestock productivity.

**Body heat production and homeothermy**

Ruminant animals are homeotherm in that their deep body temperature is maintained fairly constant with only small permissible fluctuation (37-39$^0$c ). In normal condition, body temperature remains regulated despite the very high amount of heat generated during the processes of feed consumption, digestion, absorption and utilization and also during basal metabolism (Webster, 1983).

The amount of heat an animal produces depends on its size and physiological state, its energy (ME) consumption, activity and its need to maintain body temperature. A fasted animal kept in thermoneutral environment with minimal activity produces heat which approximately is equivalent to its basal metabolic rate. This represents the minimum net energy requirement for the physiological activities vital for life (i.e. energy requirement for maintenance). As the chemical energy used for maintenance is eventually lost as heat, some relationship between heat production and body weight which gave the average value of 300 KJ/KgW $^{0.75}$ was developed (Kleiber, 1961; Blaxter, 1967).

When ruminants eat to appetite the heat production is estimated to be about 2.3 times the basal metabolic rate (Webster, 1983). If a resting animal eats to satisfy its maintenance requirement, its heat production increases on the average by 25 to 40% of the basal metabolism. In ruminants the fiber content of the diet determines the level of increase (Blaxter and Boyne, 1978).

The heat increment due to voluntary activities such as eating, standing, changing position and walking are variable and the estimated average are indicated in Table 1.

Table 1. Energy cost of activity and calculated heat increment (HI) of 300 kg steer

| Activity | Energy cost J/kg Bwt | Amount of activity on range | HI* (MJ) |
|---|---|---|---|
| Eating | 35/min | 7 h | 4.4 |
| Standing | 5.5/min | 10 h | 9.9 |
| Changing position | 55/action | 25 | 0.4 |
| Walking horizontal | 2.1/m | 5 km | 2.4 |
| Slope | 26.5/m | | 7.9 |
| **Total** | | | 25.0 |

*Heat increment calculated based on the information from Webster (1983)

Heat increment due to the synthesis of body tissues and milk can be derived from the efficiency of the utilization of ME for these purposes. Using the information from Zerbini and Alemu (1995), the heat increment during the synthesis of each product is calculated to give the results presented in Table 2.

Table 2. Calculated heat increment arising from the processes of body production

| Type product | Efficiency of ME utilization (%) | Energy retention (MJ/kg) | Heat production (MJ/kg product) |
|---|---|---|---|
| Growth (change in live weight) | 65 | 20 | 13 |
| Milk | 65 | 3.7 | 2.4 |

For the kind of steer described in Table 1. if its daily body weight gain is assumed to be 200g then the total heat production (ME maintenance + HP growth) is 49.2MJ. A thermal energy potentially capable of boiling slightly more than 100 liters of water. Thermal energy of this magnitude could burn the animal itself if it were not for the regulatory mechanism responsible for the balance of body heat production and loss.

Live animals produce heat continuously and lose it to the environment either directly by sensible means which include radiation, conduction and convection or indirectly by evaporative means. Sensible heat loss is determined by physical attributes such as air temperature incoming radiation and air movement: the ability of the animal to control it by using its regulatory mechanism is limited. The evaporative heat loss, on the other hand, can be regulated by the animal to certain minimum and maximum points (Blaxter, 1967).

The essential feature of homeothermy is that heat production is equal to heat loss with some adjustment to heat gain by sensible means; it can be represented as:-

$HP = HE \pm HCD \pm HCV \pm HR \pm HF$ (Mouteith and Mount 1974).

Where :- HP = Heat production
HE = Evaporative loss
HCD = Heat exchange by conduction
HCV = Heat exchange by convection
HR = Heat exchange by radiation
HF = Sensible heat of adjusting the temperature of swallowed food or water

**High ambient temperature and its implication on the nutrition of ruminant livestock**

Sensible heat loss can decrease to a negligible minimum in a warm or hot climate. The major and important reaction of the ruminant animal is then to enhance evaporative loss. Evaporative loss can be partitioned between cutaneous and respiratory. Cattle use both means but their cutaneous loss (sweating) is more active. Though all cattle possess sweat glands those of Bos indicus are more voluminous (Yeates, 1965). Sheep rely little on sweating and most of the evaporative loss is effected by punting (Blaxter, 1977).

There is a wide thermoneutral zone ($10^0$c to $30^0$c) in which ruminants maintain thermal balance with negligible metabolic loss. The thermoneutral zones for milking cows lie within the range of critical temperatures of $5^0$c and $20^0$c (Legel, 1988). The

critical temperature is dependent on type of animal, physiological state, nature of feed and the degree of solar radiation (Williamson and Payne, 1987; Ranjahn and Daniel, 1972). Above the upper critical temperature, the animal cannot comfortably sustain homeothermy by evaporative loss alone. It may therefore be obliged to minimize heat production through reduction in food intake and voluntary muscular activity (Webster, 1976).

In heat stress the secretion of thyroxin and triiodothyronine is restricted, metabolic processes slow down and food consumption decline (Williamson and Payne, 1978). Fibrous feedstuff exert more negative influence on appetite than concentrates in heat stress conditions.

In principle a certain impediment in food intake may be followed by improvement in digestibility. But depressed appetite resulting from hyperthermal condition is not found to have the expected kind of compensatory effect. It was in fact found to decline in heat stress regardless of the level of intake.

The total volatile fatty acid production in the reticulo-rumen and the proportion of acetic to propionic acid are negatively influenced by hyperthermal condition (McDowell, 1972). The type of fermentation that decrease acetic acid may improve the efficiency of utilization of metabolizable energy (Orskov, 1975).

Heat stress conditions stimulate the secretion of glucocoriticoids and catecholamine. The catecholamine inhibits insulin and thus glucose up-take; it on the other hand activates the mobilization of energy rich substrates from stored fats and proteins and possibly from the glycogen in the liver. Glucocorticoids stimulate the break down of the substrates and inhibits protein synthesis. The immediate metabolic consequences are therefore loss of stored energy as heat increment (energy wastage) and protein as urea and creatine (Webster, 1976). Hyperthermic steers excreted more urea and creatine with the urine; suggesting some failure in protein deposition (Colditz and Kellaway, 1972). The increase in environmental temperature which stimulates transpiration results in enhanced loss of minerals such as potassium, sodium, magnesium and chlorine (Legel, 1988). In conditions of high ambient temperature the supplementation of the diet with sodium and potassium improved the milk production of dairy cows.

Water requirement of animals increase with rising temperature probably for the purpose of replacing what is lost by evaporation and because of its direct cooling effect in the digestive tract. When the environmental temperature increased from $18^0$c to $30^0$c water intake increased by 29%. With milking cows the increase in water consumption kept on rising till the ambient temperature was about $27^0$c, beyond this it declined with decrease in dry matter intake (Winchester, 1964).

Many generalized statements indicate the adverse effects of tropical climate on growth, but some specifically show that high air temperature can depress growth rates, milk production and butter fat content (Legel. 1988; and Williamson and Payne, 1978) the reproductive functions of ruminant animals (Moule, 1970).

**The Ethiopian situation and prospects**

The direct effects of heat stress in the tropics are compounded by its indirect influence on the quantity and quality of forages. In dry conditions the availability of forages is poor and even if the supply may be adequate, the quality is low (high fiber and low protein content). Figure 1. summarizes the problems of heat stress associated

with nutritional status livestock and some interactions between direct effects as well as between direct and indirect effects.

The mean annual temperature in the Dega, Weinadega and Kola zones of Ethiopia range between 10°c to 15°c, 15°c to 20°c; and 25°c respectively. Though the annual mean temperature vary little the range between day and night temperature is considerably high; it varies by about 20°c to 40°c in all places. Seasonal variation is not distinctly observed as the sun is always high in the tropics. But there is some increase between March and September since this is the high sun period. The rain and cloud of the summer can modify the day temperature in the rainy season. Ethiopia is one of the countries that receive maximum intensity and duration of sunshine over the globe; as much as 4000 bright sunshine hours are received in a year. Most parts of Ethiopia receive over 7 hours of bright sunshine daily. It is only during the summer rainy season in the high lands of central and south western Ethiopia, when there is much cloud cover, that the daily duration of sunshine is about 5 hours.

Ethiopia receives 7.4 to 6.6 kwh/$m^2$ of solar radiation. This abundant solar energy received for about 7 hrs daily in most parts could be beneficial in economic and social development but it can also impose a negative impact on livestock productivity in conditions of ecological imbalance.

In Ethiopia native pasture is the major source of feeds for ruminants both in the areas of mixed agriculture or pastoralism. It is, however, neither quantitatively nor qualitatively adequate to support profitable animal production (Seyom and Zinash, 1989). Unsupplemented pasture is barely capable to maintain body weight (Solomon and Solomon, 1995).

Since concentrate supplements are not readily available and since they are relatively expensive they are rarely used in animal production. Instead, on-farm grown forage legumes are suggested as good alternates (Nnadi and Haque, 1988).

Till to date there is no information about any specialized effort to grow feeds for livestock. Farm crop residues when ever available are the major complimenters to range grass. The under-sowing of annual forage legumes with cereals could increase forage production with unmarked effect on the yield of main crop (Tessema, 1993). But, the simultaneous production of food and forage crops is not a common practice (Lulseged *et al..*, 1987).

The losses of trees are known to greatly contribute to soil degradation and to the unsustainability of agricultural system. Ethiopia which has already lost more than 97% of its forest is one of the countries suffering from such situations. Unfortunately the little appreciation to the great values of trees in agriculture has mainly been linked to soil fertility.. Current knowledge however, indicates equally important additional role in providing shelter to pasture and livestock; and as good food particularly in the dry seasons (Bird *et al.*, 1984).

In a country where feed supply is meagre; the quality and quantity of pasture deteriorate with the dry season ; and where lack of natural shelter exposes animals to heat stress the concept of multipurpose trees should be invoked by policy-makers and scientists as a means of solution.

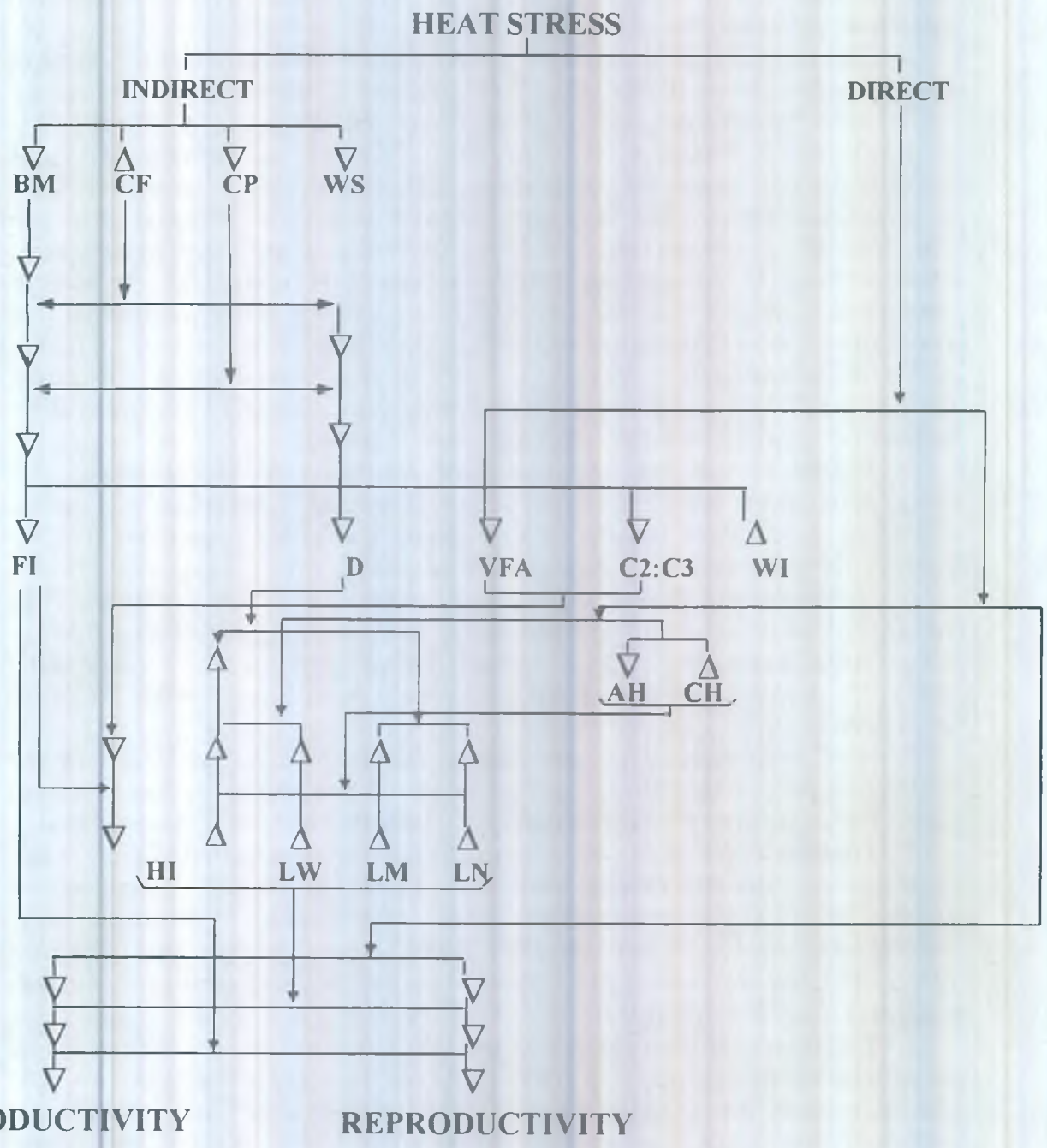


FIGURE 1. The impact of heat stress on the nutrition of ruminant livestock (Δ = increase; ∇ = decrease).

BM = forage biomass; CF = crude fiber; CP = crude protein;
WS = water supply; FI = feed intake; D = digestibility;
WI = water intake; AH = anabolic hormone; CH = catabolic hormone;
HI = heat increment; LW = loss of water; LM = loss of mineral;
LN = loss of nitrogen

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# Utilization Of Tef Straw As Livestock Feed: Research Review

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## Abstract

Availability of tef straw in relation to ruminant population is estimated for each region and potential areas for tef straw utilization as livestock feed are identified. Research efforts made in characterizing nutritive values of tef straw and animal performances on tef straw based diets are reviewed. About 13 million tons of crop residues are produced in the country annually and tef straw accounts for 25% of the total production. Availability of tef straw varies from region to region and the major tef growing regions account for 80% of the total straw production and they share 50% of the ruminant population. Nutritional constraints of tef straw utilization include low N concentration, low voluntary intake, low amino acid supply at a tissue level and low glucogenic potential. In its nutritional quality tef straw stands first among cereal straws and more benefits could be realized if strategic supplementation procedures are used. Mechanisms how responses on tef straw utilization could be elicited are highlighted and future research directions are identified.

## Introduction

The demand for livestock commodities in developing countries is expected to grow at 4.5% per year thus resulting in a 2.4 fold increase between 1980 and 2000 in the annual combined value of meat, milk and eggs. In some countries, the annual consumption of meat is estimated currently to be rising by 6.7% and this high rate of increase is expected to continue (Harvosky, 1981).

Livestock production systems should undergo radical changes than crop production if expectations from this sector are to be fulfilled. Under the impact of raising demand output would need to increase considerably faster for animal production (4.7%) than crop production (3.6%).

Trends observed in increasing livestock output are mainly through increasing livestock numbers but not productivity per head (Leng *et al.*,1992). The rate of herd growth mainly depends on the pressure already existing on the availability of feeds.

As human population increases more and more land will be devoted to grain production and only marginal lands will be left for feed production. The ruminants, will therefore, have to depend increasingly on crop residues for their basal diet. In Ethiopia, crop residues form an integral part of feed resources especially during the dry season. The type of crop residue available for livestock feed depends on the agro-ecology or the farming system prevailing in an area. In the medium and low land areas residues of maize and sorghum are the dominant ones while in the medium and high land areas, cereal crop residues like tef straw, barley straw and wheat straw are the major crop residues used to augment the year round feed budget. Because of its production potential and nutritive value, research on utilization of crop residues in Ethiopia has focused on tef straw for the last few years. In its production potential, tef straw stands second to maize among crop resides and in its nutritional quality, it is the best among cereal crop residues. Research efforts in understanding nutritional characteristics of tef straw ranged from laboratory studies (chemical analysis, in vitro digestibility) to in vivo studies (digestibility, voluntary intake, rumen degradability and animal response studies). This paper comprehensively describes the availability of tef straw, research findings and opportunities for better utilization of tef straw as livestock feed.

### 1.1. Availability of tef straw

There has been no studies on the availability of crop residues in relation to their potential for feeding livestock in Ethiopia. Estimates on availability of crop residues usually depend on harvest indices under research condition assuming certain field losses (Nordbloom,1988). Estimates of FAO (1984) suggest a factor of 1 which would mean a harvest index of 50%. However, reported harvest indices for tef are usually in the ranges of 24-37% (Seyfu Ketema, 1992; Seyoum *et al.*, 1994). Using recommended conversion factors (Nordblom, 1988) a total of 13 million tons of crop residues are annually produced in Ethiopia (Table 1). Tef straw stands second in its total production and it contributes about 25% of the total straw production.

The availability of tef straw varies from region to region and farmers also have alternative uses of tef straw. A survey made in the central zone of Ethiopia (Zinash and Seyoum,1989) indicated that about 30% of tef straw is used for other purposes and 70% is effectively used for livestock feed suggesting that 2.5 million tons of tef straw is available annually for livestock feed. About 80% of the total production of tef straw is produced in the administrative regions of Shewa, Gojam, Gonder, Wello and Wellega where 50% of the total ruminant population in the country is found (Table 2). The available tef straw per ruminant population per annum varies from 3 kg in Bale administrative region to 168 kg in Gojam with a mean of 68 kg per tropical livestock unit per annum.

Table 1. National estimates of crop residues produced per annum (7 years average, 1979\86)[a]

| Residue | Factor | Quantity ($10^6$ ton) |
|---|---|---|
| Tef | 3.0 | 3.51 |
| Sorghum | 3.0 | 3.52 |
| Millet | 3.0 | 0.06 |
| Maize | 2.0 | 2.87 |
| Barley | 1.2 | 1.16 |
| Oats | 1.2 | 0.06 |
| Pulse | 1.0 | 0.76 |
| Wheat | 0.8 | 0.56 |
| Total | | 13.05 |

Sources [a] Central statistics office (1987)
[b] Conversion factors suggested for East Africa, Nordbloom, 1988 (except tef straw)

Table 2. Regional availability of tef straw in relation to livestock population

| Region | Available Tef straw+ ($10^3$ ton) | Ruminant population ($10^6$)++ | Residue (kg)+++ per AU per annum |
|---|---|---|---|
| Arsi | 77 | 1.8 | 43 |
| Bale | 6 | 2.3 | 3 |
| Gemugofa | 16 | 1.1 | 14 |
| Gojam | 522 | 3.1 | 168 |
| Gonder | 277 | 2.0 | 139 |
| Hararge | 33 | 3.2 | 10 |
| Illubabor | 79 | 0.8 | 99 |
| Kefa | 110 | 1.7 | 65 |
| Shewa | 724 | 7.0 | 103 |
| Sidamo | 44 | 3.4 | 13 |
| Tigrai | 109 | 2.6 | 42 |
| Wellega | 250 | 2.3 | 109 |
| Wello | 242 | 3.0 | 81 |

[+] Mean crop yields of 1979\1986 (CSO, 1987), conversion factor of 3.2 and 70 % effective uses were used; [++] MOA (1982); [+++] 1AU = 1 cow, or 5 goats or 5 sheep (Nordblom ,1988)

## 2. Nutritional characteristics of tef straw

### 2.1. Chemical composition

Tef straw is characterized by low CP, EE but high cell wall and cell wall constituents (CWC) (Table 3). Its crude protein content is lower than the threshold required to put an animal in a positive N balance and its fiber content is also higher than the value suggested to limit intake of animals. However, its crude protein content is higher than wheat straw and close to that of barley straw and native hay.

Table 3. Chemical composition of tef straw and other dry roughage (% DM basis)

| Feed | DM | EE | Ash | CP | NDF | ADF | lignin |
|---|---|---|---|---|---|---|---|
| Tef straw (21)+ | 92.4 | 1.7 | 7.1 | 6.0 | 74.5 | 42.4 | 7.7 |
| Wheat straw (10) | 92.9 | 1.6 | 7.2 | 3.9 | 77.2 | 48.2 | 7.9 |
| Barley straw (10) | 93.1 | 2.3 | 8.3 | 6.2 | 73.2 | 45.0 | 6.3 |
| Native hay (9) | 92.2 | 1.5 | 9.5 | 6.6 | 73.8 | 45.4 | 8.3 |

+ Number in parenthesis indicates number of samples analyzed
Source: Seyoum and Zinash (1989)

### 2.2. Digestibility and energy value tef straw

In vitro digestibility and energy value of tef straw are higher than cereal crop residues (wheat or barley straw) and closer to that of native hay (Table 4). Its in vitro digestibility is higher than the level required to support maintenance requirements of the animals and marginal to the level which supports animal production.

Table 4. *In vitro* digestibility and energy values of tef straw and other roughage

| Feed type | n | IVDOMD(%) | EME (MJ/Kg) |
|---|---|---|---|
| Tefstraw | 14 | 53.20 | 8.35 |
| Wheat straw | 8 | 45.50 | 7.14 |
| Barley straw | 10 | 48.03 | 7.60 |
| Native hay | 9 | 54.50 | 8.60 |

## 2.3. Voluntary intake of tef straw

Reported voluntary intake of tef straw varies from 1.63% to 2.5% and from 1.87% to 1.91% of live weight for small ruminants and large ruminants respectively (Table 5). The mean voluntary intake of tef straw reported so far is 46 g\kg$^{0.75}$ for small ruminants which is lower than the level expected (79 g\kg$^{0.75}$) for a good quality forage (Leng, 1985). Fiber (cell wall) intake of tef straw varies from 30-42 g\kg$^{0.75}$ which is in agreement with the theory that sheep can consume about 40 g cell wall per Kg metabolic body size. Calculated cell wall intake for large ruminants is fairly constant (52.7 g\kg$^{0.75}$) and higher than that of small ruminants. Compared to other crop residues tef straw has an intermediate voluntary intake (Table 6). Voluntary intake of tef straw is higher than most cereal crop residues.

Table 5. Reported voluntary intake of tef straw

| | Dry matter intake | | NDF intake | |
|---|---|---|---|---|
| Animal | %LW | g\kg $^{0.75}$ | g\kg $^{0.75}$ | Source |
| Sheep (17.9) | 1.81 | 37.3 | 29.69 | Nuwanyakpa and Butterworth, 1986 |
| sheep (20) | 2.30 | 48.6 | 37.68 | Butterworth and Mosi, 1986 |
| sheep (21) | 2.50 | 52.6 | 41.55 | Bonsi et al, 1994 |
| calves (167) | 1.91 | 73.1 | 53.61 | Abule, 1994 |
| heifers (203) | 1.87 | 70.5 | 51.80 | Olayiwale et al 1986 |

Table 6. Comparative voluntary intake of tef straw and other crop residues

| Fee | d%L | g\kg$^{0.75}$ |
|---|---|---|
| Tef straw | 2.3 | 48.6 |
| wheat straw | 2.1 | 44.4 |
| oats straw | 2.7 | 57.1 |
| maize stover | 2.0 | 42.3 |

source: Butterworth and Mosi, 1986

## 2.4. Rumen degradability characteristics of tef straw

Ruminal degradability profiles of tef and other roughage are given in table 7. Tef straw has a higher potential degradability than barley straw but similar to that of native hay. Since ruminal degradability parameters of fibrous feeds can explain most of the variations (r= 0.95) in feed quality and animal response (Ørskov, 1989) it is appropriate to expect more animal production on tef straw based diets than other crop residues.

Table 7. Nylon bag dry matter disappearances of tef straw and other roughage (%)

| Feed | Dry matter disappearances at each incubation hour | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0 | 9 | 24 | 36 | 48 | 72 | 96 |
| Tef straw | 22.2 | 30.9 | 45.3 | 54.2 | 58.2 | 67.9 | 70.1 |
| Barley straw | 22.6 | 27.6 | 34.9 | 38.7 | 45.3 | 47.6 | 50.5 |
| Native hay | 25.5 | 30.7 | 43.6 | 55.6 | 61.4 | 66.0 | 68.4 |
| Oats hay | 37.0 | 41.2 | 55.3 | 64.0 | 68.8 | 70.7 | 72.3 |

## 3. Animal performance on tef straw based diets

### 3.1. Unsupplemented diets

Because of its low N, high cell wall and slow digestion, animals kept on a sole tef straw diet can not maintain their N balance. Especially growing animals may lose weight due to their high N requirement. Losses up to 75 g\day were reported for young calves fed on a sole diet of tef straw (Abule, 1994). Estimated nutrient supply from tef straw when fed alone to ruminants is given in table 8. Energy supply is marginal to maintenance requirement while the protein supply is far below the maintenance requirement. Growth rate or production level of animals fed on a sole tef straw diet is primarily limited by the supply of essential amino acids to the tissues.

Table 8. Nutrient supply from tef straw when fed alone to ruminants

| Animal | LW kg) | DMI* (%LW) | Nutrient supply | | Requirement** | | Nutrient supply as % of requirement | |
|---|---|---|---|---|---|---|---|---|
| | | | Energy (MJ\day) | protein (kg\day) | Energy (MJ\day) | protein (kg\day) | Energy | Protein |
| Sheep | 15 | 2.2 | 2.76 | 0.0198 | 3.0 | 0.036 | 92 | 55 |
| | 25 | 2.2 | 4.59 | 0.0330 | 4.3 | 0.053 | 107 | 62 |
| | 35 | 2.2 | 6.43 | 0.0462 | 5.6 | 0.068 | 115 | 68 |
| Cattle | 250 | 1.8 | 37.58 | 0.2700 | 30.9 | 0.337 | 122 | 80 |
| (Steer) | 350 | 1.6 | 46.76 | 0.3360 | 40.9 | 0.432 | 114 | 78 |
| | 450 | 1.5 | 56.36 | 0.4050 | 49.5 | 0.528 | 114 | 77 |

* Average voluntary intake (dry matter intake) of tef straw based on local data and voluntary intake for cattle was adapted from Kearl (1982)

** Maintenance requirement (Kearl,1982)

### 3.2. Supplemented diets

#### 3.2.1. Nitrogen supplementation

In ruminant diet sources of nitrogen can either be from dietary protein which escape fermentation in the rumen, microbial protein synthesized in the rumen, endogenous secretions of protein in the mouth and stomach and from epithelial cells sloughed off from the wall of the digestive tract. Dietary nitrogen of ruminants can be considered in two categories: rumen degradable nitrogen (RDN) which is used for microbial protein synthesis and undegraded dietary protein (UDP) which escapes fermentation and which is digested in the intestine. The optimal RDN requirements are considered to be 30 g N\kg of organic matter fermented in the rumen (ARC, 1980). Nutrient release of tef straw suggest that N release is merely less than 1 g\100 g OM and it is 70% below the level required for optimal fermentation and microbial protein synthesis (Table 9). It is, therefore, imperative that a source of RDN should be included in tef straw based diets for optimal utilization.

Table 9. Nutrient release synchrony index of tef straw

| Parameter | Incubation hour | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0 | 9 | 24 | 36 | 48 | 72 | 96 |
| OM release(g\100 g) | 20.65 | 28.74 | 42.13 | 50.40 | 54.13 | 63.15 | 65.10 |
| N release (g\100 g) | 0.20 | 0.27 | 0.40 | 0.48 | 0.51 | 0.60 | 0.62 |
| Synchrony index | 0.32 | 0.31 | 0.32 | 0.32 | 0.31 | 0.32 | 0.32 |

Protein supplements vary in the extent to which they are degraded in the rumen and this is of practical importance when considering the mechanisms of responses in intake and animal production to forage or by-product concentrate supplements. The degradability of various herbaceous legumes, browse species and oilseed cakes have been shown to be high and they can be used as good sources of RDN (Seyoum, 1994). Sources of protein at the small intestine are also required to support high producing animals or growing animals kept on a basal diet of tef straw. Animal responses to supplementation of tef straw using N sources could produce variable results depending whether the supplement is extensively degraded in the rumen or it serves as a source of UDP. Higher animal performances were reported for slowly degrading N sources with high UDP than rapidly degrading ones with low UDP (Lema, 1993).

#### 3.2.2. Energy supplementation

As indicated in table 8 the energy supply of a sole tef straw diet is marginal to maintenance requirement of the animals. Animal production on such a diet, therefore, requires supplementation with energy source especially fermentable carbohydrate. The provision of readily fermentable carbohydrate improves utilization of ammonia for microbial growth. However, excess readily fermentable carbohydrate can adversely

affect the digestion of cell wall components. The addition of concentrate containing sugar or starch in the diet can result in a reduction in the rate of digestion and it can be of practical significance if the level of concentrate feeding is in excess of 0.5% live weight because it reduces roughage intake. Excess inclusion of concentrate feeding in ruminant diet is detrimental to the animal for the following reasons (Jung, 1986):

1. The amount of amino acid N absorbed by the animal will be reduced and the form of digestible energy absorbed will be more from VFA and less from digestion of microbes and
2. large population of protozoa and reduced population of microorganisms responsible for digestion of fiber

Physiological responses and constraints to concentrate supplementation of crop residue suggest that optimum levels of fermentable carbohydrate should be included in tef straw diets. Available data suggest that a ration based on tef straw needs supplementation up to 50% of the ration dry matter for fattening (IAR,1976). From the results of experiments conducted in Zimbabwe using crossbred animals it was demonstrated that optimum levels of cane molasses in fattening diet is 30% (Table 10). Under Ethiopian condition inclusion rate of 40% of cane molasses in fattening diet was noted to support maximum live weight gains of local animals (Jepsen and Creek, 1976).

Table 10. Live weight gain (g/day) of crossbred cattle fattened with different levels of molasses

| | Level of molasses (%) | | | | | |
|---|---|---|---|---|---|---|
| Anima | 0 | 10 | 20 | 30 | 40 | Mean |
| Steers | 1.36 | 1.57 | 1.50 | 1.54 | 1.31 | 1.46 |
| Heifers | 1.33 | 1.51 | 1.61 | 1.40 | 1.29 | 1.43 |

Source: Sibanda *et al.*, 1987

### 3.3.3. Mineral supplementation

Studies on content and availability of minerals in crop residues in Ethiopia suggested that diets based on crop residues are unlikely to supply adequate Na and are marginal- to deficient in P, Cu and possibly Zn.

### 3.3.4. Animal performance on supplemented diets

Animal performance on supplemented tef strarw diets vary considerably depending on the type and level of supplemnts. Supplemented tef straw diets can support a mean live weight gain of about 500 g/day for large ruminants and 90 g/day small ruminants. Concentrate supplementation of tef straw diet was noted to noted to support gain of 629 g/day for cattle which was about 78 %, 56% and 32% higher wheat straw, oats hay and native hay (IAR, 1976). It appears that tef straw is a good quality roughage

and it can be used successfully for fattening purposes with locally available agro-industrial by-products, herbaceous legumes or browse species.

Table 11 Mineral content of tef straw and other roughage[a]

| Feed | K | Na | C | P | Mg | Fe | Mn | Zn | Cu |
|---|---|---|---|---|---|---|---|---|---|
| | g\kg | | | | | mg\kg | | | |
| Tef straw | 11.7 | 0.3 | 4.3 | 1.6 | 1.9 | 170 | 59 | 26 | 6.5 |
| Wheat straw | 14.8 | 0.3 | 4.1 | 1.3 | 1.5 | 325 | 78 | 11 | 3.0 |
| Barley straw | 10.7 | 0.5 | 4.6 | 1.9 | 1.4 | 175 | 90 | 12 | 5.0 |
| Critical level | 6.5 | 0.8 | 2 | 1.4 | 1 | 50 | 40 | 30 | 8 |
| Source[b] | 1 | 2 | 1 | 3 | 4 | 4 | 4 | 4 | 1 |

[a] Kabaja and Little (1989)

[b] Dietary critical levels were adapted from 1. NAS (1984) 2. Little (1987) 3. Little (1984) and 4. McDowell (1985)

Table 12. Growth performance of ruminants fed on a basal diet of tef straw

| Animal | Average weight(Kg) | Supplement type | level (%) | growth (g) | source |
|---|---|---|---|---|---|
| Native steers | 186 | concentrate | 50 | 626 | IAR, 1976 |
| Native steers | 193 | concentrate | 50 | 438 | IAR, 1976 |
| Calves(crossbred) | 158 | forage legumes | 22 | 207 | Abule, 1994 |
| Calves(crossbred) | 158 | forage legumes | 45 | 503 | Abule, 1994 |
| local sheep | | forage legumes | 29 | 37 | Michael *et al.*,1989 |
| local sheep | | forage legume | 40 | 67 | Lema, 1993 |
| local sheep | | browse | 25 | 48 | Reed *et al.*,1991 |

## 4. Impilications for future rresearch directions

### 4.1. Strategic supplementation

Better utilization of tef straw relies on appropriate supplements and level used in livestock feeding. Research efforts should, therefore, be geared toward understanding the mechanisms how responses on tef straw based diets can be elicited using contemporary knowledge of ruminant nutrition. Choice of appropriate supplements should be based on the capacity to supply RDN, UDP, and fermentable carbohydrates. Emphasis should be given to the need for synchronizing release of nutrients for better utilization of the basal diet and supplement.

### 4.2. Exploitation of varietal differences in straw quality

Currently, there is a growing interest in exploitation of varietal differences within a species of crop residue. In contrast to the situation with forage grass no deliberate attempts have been made to include straw quality in cereal breeding or selection program. In a mixed crop livestock production system of the Ethiopian highlands, there seems to be a potential for selecting a cultivar high in grain yield and straw quality. Studies on varietal differences in straw quality and inter-relationships of grain yield, straw yields and quality should be given emphasis. Choice of variety could be based on potential utility index (grain + digestible straw yield) than grain yield alone.

### 4.3. Exploitation of genetic basis of animals for better utilization of tef straw

Among various ways by which genetic variability of animals in crop residue utilization arise, differences in ability to digest nutrients should receive reasonable attention. Available information so far is in favor of Bos indicus animals (Zebu type) than Bos tarus (or their crosses) (Karue *et al.*,1972, Howes *et al.*, 1963, Philips *et al.*, 1960 and Church, 1986).

When environmental stress is high, native breeds may outperform exotic breeds and superiority in genetic potential can only be expressed when environmental conditions are favorable. Genotype-environment interaction are important in the tropics. Genetic basis for differences in gut volume reflected in differences in fractional outflow rates and particle size have been noted between and within breeds of ruminants (Ørskov, 1989). It is, therefore, appropriate to look into options for better utilization of tef straw by using animals better adapted to tef straw.

Quite substantial amount of tef straw is annually produced in the country and in its nutritional quality it stands first among cereal crop residues produced locally. Animals fed on a sole tef straw diet can not maintain their live weight mainly due to inadequate protein supply. Supplemented tef straw diets can support an average daily gain of 500 g for large ruminants and 50 g for small ruminants. More benefits of tef straw utilization can be realized through strategic supplementation with RDN, UDP, fermentable carbohydrate and mineral sources. Choice of appropriate supplements and level should be based on fermentation characteristics than gross nutrient content.

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# Preliminary Study On Honey Plants Around Holetta

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## Abstract

All kinds of natural vegetation that was seen foraged by bees were collected and taxonomically identified. Their nature, habitat, flowering period and their importance to honey bees were determined. Honey samples harvested at the same period were analyzed using the revised method of melissopalynology. Fifty dominant and 86 minor honey plant species which are growing mostly on open and cultivated land were identified. The species include both naturally growing and cultivated plants with more herbaceous type. Most of honey plant species of the area were flowered and visited by honey bees during spring (September- November). The time from the second week of October to the end of November is the main honey flow period during which time honey is harvested at large and honey of this period is mainly based on herbaceous source (*Creopsis hornonia and Brassica napus*). The last two weeks of June was the time for minor honey flow and during this period honey is mainly made from Eucalyptus species.

## Introduction

Ethiopia is endowed with various climatic condition, topography, and wide range of altitude favoring the presence of different natural vegetation that includes high forests, bushes, herbs, weeds and undergrowth. The presence of these different natural vegetation made the country the best home for honey bees. In the area where there are various kinds of honey plants, better honey yield is certain than the area with poor natural vegetation. More over, the yield of honey depend on some characteristics of plant nature. Flowers heads, duration of flowering, floral structure and sugar concentration of flower are some of the factors governing honey production. Plants with good flower heads, may not be foraged by bees while others equally flower but not as good as expected.

This study includes determination of predominant, dominant and less common honey yielding plants that are found near and around Holetta Bee Research and Training Center. The result of the study would help to give information regarding the types of honey plants, flower nature, period of flowering and others factors related to honey production. The main objective of this study was to determine predominant honey plants and their important honey bees, habitats and their flowering period to draw honey flow time of the study area.

The main objective of this study was to determine predominant honey plants, habitats and their flowering period to draw honey flow time of the study area.

## Materials and methods

This study was undertaken at Holetta Bee Research and Training Center which is located 44 km west of Addis Ababa on the way to Nekemte. It has an altitude of 2400 m above sea level and covered mainly by cultivated Eucalyptus spps., cultivated crops and natural weeds. The study site also covered areas like Welamo sefer, Misrak Sholaber, Sadamo, Suba and Menagesha and Cheshier home.

Estimates of land utilization pattern of Wolmera wereda suggest grazing area of 9614 ha, cultivated land of 23152 ha and forest area of 7040 ha. Flowering plants that were seen foraged by honey bees were collected and their nature, habitat, flowering time and potentiality were registered through out the seasons for four consecutive years (1985-1988) and processed and preserved in herbarium of Holetta Bee Research Center, according to the revised method of collecting and making herbarium specimen. Taxonomic identification of the samples were done in collaboration with Addis Ababa University, Department of biology.

To determine the major and minor sources of honey, pollen analysis of eight honey samples harvested during the study period (1985 -1988) was done at Holetta Bee Research Center using the revised method of melissopalynology.

## Results and Discussion

So far 50 major honey plants were discovered as source of surplus honey and 86 minor honey plant varieties that support day to day activities of honey bees. The type of honey plants of the study area are dominated by herbaceous than trees and shrubs (table 1). This could be due to the small area (10.16%) covered by forest mainly based on cultivated trees (Eucalyptus spps and Junipers spps). Hence it is not unusual less number of different honey trees and bushes than herbaceous varieties that could grow on large area of the region.

Table 1. Categorization of samples into plant nature.

| Nature of honey plant | Number of honey plant variety | Percentage |
|---|---|---|
| Herbs | 103 | 76 |
| Shrubs | 17 | 12 |
| Trees | 16 | 12 |
| Total | 136 | 100 |

Honey plants of the study area include both naturally growing and cultivated plants. The former is abundant than the latter groups. Weeds are the major naturally growing honey plant while food crops were the dominant ones from cultivated honey plants (table 2).

Table 2. Percentage distribution of investigated samples.

| Main groups of honey plants in the group | Types of honey plants included | Percentage proportion | Total percentage of the group |
|---|---|---|---|
| Natural growing plants | weeds | 40 | 64 |
| | Trees and bushes | 24 | |
| Cultivated plants | Food crops & forage | 22 | 36 |
| | Ornamental flowers | 14 | |

Forest trees alone could not be considered as major source of nectar (Ayalew, 1989). During blooming season, therefore, the combination of forest trees, shrubs, field flowers, undergrowth and cultivated crop spps are necessary to have high honey production. Hence the region has all types of honey plants that could contribute for honey yield. Even though land mass of cultivated land is by far larger (23152 ha.) than the open land habitat (10707 ha.), it contains less number of honey plant varieties than open land. This is may be due to the fact that its most part is occupied by the same spps of crops.

The type of food source obtained from honey plants vary from plants to plants. Honey plants of this region offer nectar and pollen. Number of honey plant varieties supplying nectar and pollen separately are nearly equal. While those offering both nectar and pollen come next, which is little less than those source of nectar & pollen separately (table 3).

Table 3. Honey plants as food source to bees

| Kind of Food source to bees | Percentage by plant variety |
|---|---|
| Nectar | 34 |
| Pollen | 34 |
| Pollen plus Nectar | 32 |

The basic dietary constituents of adult bees are nectar of honey and pollen. Honey is essentially a carbohydrate material with 95 - 99.9% of solid being sugars. It almost devoid of proteinaceous materials and contains components of important carbohydrate

metabolism. Thus honey is source of energy for bees.

Health of bee colonies during brood rearing season is as dependent on pollen as it is on honey. Pollen is source proteins, fatty substance, minerals and vitamins, that are necessary during production of larval food and development of newly emerged bees. A colony does not rear brood if it doesn't have pollen (Haydak, 1973a). Older bees can rear brood with out consuming pollen, but they do this at expense of their own bodies and moreover the amount of brood produced is rather small. Therefore, to support strong and healthy colony and high yield of honey, the presence of different honey plants offering nectar and/or pollen are equally important. Honey plants discovered at the study area have the potential to serve as food sources food source to honey bee colonies.

Although there are important variation from year to year, the region has two rainy seasons. "the big rainy season" which occurs from mid June or early July to September and "small rainy season" which vary in intensity and length, normally occurring in mid February to April. The end of these rainy seasons, about September and April are followed by hot temperature, which is convenient for plants to flower (bloom). The majority of honey plants of the study area were seen in flower during September to November with the peak being October.(fig.1). This period is not the only time in which various number of honey plant spps come into bloom, but also the time in which major honey plants abundantly bloom and bees are so active in collecting pollen and/or nectar. As the result of this, the period from 2nd week of October to the end of November is the time in which much honey yield of the year is obtained at the study area. Thus this period can be considered as main or major honey flow period of the year.

Honey plant varieties flowering during period of March to May are small in number and they are dominated by Eucalyptus spps. These honey plants of Automen start flowering at the beginning of March and reach their peak from mid April to end of May. To this effect the first two weeks of June is the second period of the year in which honey is cropped. Honey yield expected during this period is less than the yield of main flow period. Hence this period is considered as the minor honey flow period of the study area. Therefore honey flow period of a given area is not only dependent on the number of plant varieties flowering at a place but also on the presence and abundance of major honey sources.

On top of this, the flowering period of honey plants vary from year to year based on weather and climatic condition of the year. Some times it is shifted to early or late of the above mentioned flowering calendar.

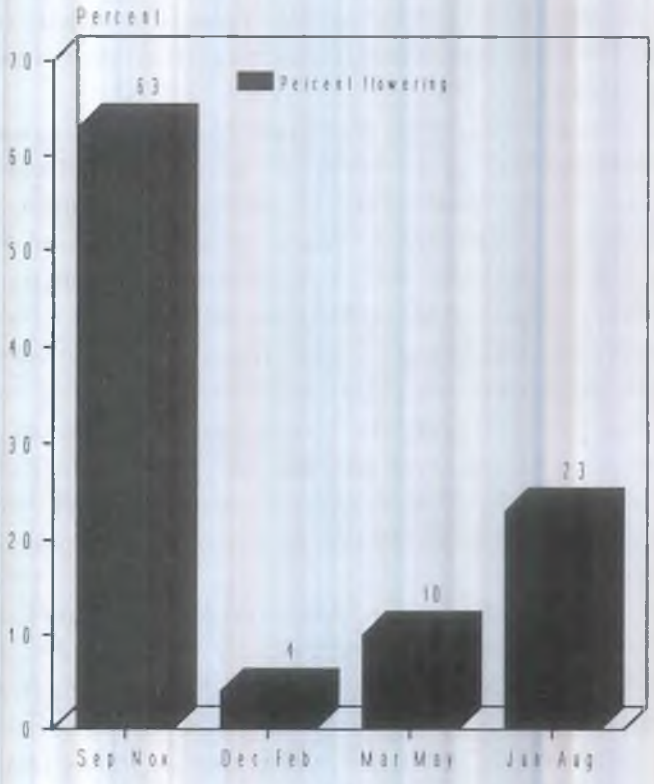


Fig. 1. Flowering period of honey plants in the study area

The scarcity of bee forage around Holetta occurred both in summer and winter, from mid of June to the end of August. Summer is dearth period in which no plant come into bloom except *Vernonia amygolatina*, which flowers from mid of December to mid of February.

Number of honey plant varieties flowering during winter is next to the major flowering period, spring. But these plants are more of weeds which are more minor source of bee forage and found scattered. Moreover it is period in which the region receives heavy rain fall. This heavy rain have impact on dilution of sugar concentration of nectar of honey plants in flower and also may wash down the pollen. Thus the weather condition of this period causes inaccessibility of food source even though there are honey plants in flower. And further more limits the activities of bees in hive.

Therefore to over come the starvation of colony during summer it is important to plant plenty of *Vernonia* spps and other herbaceous honey plants in the apiary using irrigation system. It is also advisable to feed colonies inside the hive during winter. The extent to which a given honey sample is derived from different plant source can be deduced from its frequencies of pollen in it (Louveax.J etal 1978). Hence according to the investigation *coreopsis* and *Brassica* napus are secondary pollen source of major honey flow, while Plantago Lanceolatum is important minor pollen source (table 4).

During major honey flow period great number of honey plants are seen in flower abundantly & visited by bees frequently, thus honey of this period is multiflora source which are equally important source of the forage and therefore this causes reduction of frequency occurrence of each honey plants of this period.

On the other hand due to the absence of much competent honey plants during minor honey flow, Eucalyptus spps was frequently visited by bees. Therefore Eucalyptus is predominant honey source of the period. The frequency occurrence of pollen grains of each honey plants in honey sample varies from year to year. This may be due to the flowering tendency of each honey plants could differ depending on the weather condition of the year.

Variety of honey plants studied and identified were few as compared to the existing flora of the area. Hence further study would be necessary to evaluate the richness of the area in honey plants. Further more the detail research on nutritional value of these honey plants of the area is highly important.

Table 4. Pollen analysis of honey samples collected from the campus of Holetta Beekeeping and Training Center (1985 - 1988)

| Honey flow period | Types of pollen grains in the samples | Percentage occurrence of grains in each sample at different period of year | | | |
|---|---|---|---|---|---|
| | | 1985 | 1986 | 1987 | 1988 |
| Oct. to Nov | Brassica napus | 46 | 27 | 8 | 31 |
| | Corcopsis bornnonia | 44 | 17 | 42 | 26 |
| | Eucalyptus spps | 3.0 | 8 | 3.8 | 6.0 |
| | Plantago Laceolatum | 3.0 | 16 | 14 | 15 |
| | Vicia sativia | 1.8 | 3 | - | 10 |
| | Acacia spps | 0.9 | 3 | 4 | - |
| | Vernonia amyglotian | 0.2 | - | - | - |
| | Ruta | 0.5 | - | - | - |
| | Corriandrum sativum | 0.8 | - | 0.2 | - |
| | Trifolium spps | - | 11 | 11 | 1.6 |
| | Medicago sativa | - | 11 | 7 | 10 |
| | Prunus prosica | - | - | 4 | - |
| | Unidentified | 0.8 | - | 6 | - |
| | Eucalyptus spps | 76.6 | 81.4 | 83.0 | 95.0 |
| | Correopsis bornonea | 9.0 | 5.0 | 3.0 | - |
| | Brassica napus | 8.0 | 8.0 | 1.0 | - |
| | Plantago lanceolatum | 2.3 | 4.4 | 9.0 | - |
| | Vicia sativa | 1.9 | - | - | - |
| | Medicago sativa | 1.9 | - | - | - |
| | Acacia spps | 1.9 | - | - | - |
| | Linum sativum | 0.4 | - | 1.0 | 0.28 |
| | Triflium spps | - | - | - | - |
| | Salvia spps | - | - | - | 0.6 |
| | Phacelia tenactifolia | - | - | - | 3.64 |
| | Unidentified | - | - | 2.0 | 0.16 |

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# Evaluation of Napier (*Pennisetum purpureum*) and Pennisetum Hybrids (*Pennisetum purpureum x Pennisetum typhoides*) in the Central Highlands of Ethiopia

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## Abstract

Variation in yield performances and nutritional quality of pennisetum and pennisetum hybrids were evaluated in the central highlands of Ethiopia in a set of two trials. Trial one evaluated agronomic performances (dry matter yield, plant height and frost tolerance) and nutritive values (chemical composition, *in vitro* digestibility) of local variety of napier grass and nine accessions of pennisetum hybrids. Best-bet accessions were selected based on yields of crude protein and digestible organic matter per ha. It was found out that accessions 16835 was the best followed by accessions 14984, 16786 and 16834. In trial two, the effect of cutting height (0.5 m, 1.0 m and 1.5 m) and accessions on agronomic performance and quality (chemical composition, *in vitro* digestibility and rumen degradability) were compared in a split plot design, where accessions were used as main plot and cutting heights were used as sub-plot. The pennisetum accessions and cutting heights had a significant ($P<0.01$) effect on annual DM yields. Among the cutting heights studied, cutting at 1.0 m height produced the highest yield (5.2 t/ha) which was 2.0 and 1.0 t DM $ha^{-1}$ higher yield than cutting at 0.5 and 1.0 m respectively. Accession ILCA no 14984 produced annual DM yield of 5.4 t DM $ha^{-1}$ while the other accessions had similar yield potentials of 4.3 to 4.8 t DM $ha^{-1}$. Cutting height had remarkable effect on crude protein content and *in vitro* organic matter digestibility (IVOMD) than on dry matter, ash, and fiber contents. The mean CP content of the accessions at 0.5, 1.0 and 1.0 m height of cutting were 20.2, 15.3 and 13.3 %, respectively while the respective IVOMD of the three cuts were 74, 72 and 62 %. Based on yield performance and nutritional characteristics, the optimum cutting heights of pennisetum in the central highlands of Ethiopia is 1.0 m. The best accession in overall performance was accession No 14984 followed by accession No 16835 and 16834. Further studies using intake and animal performance trials are required to develop pennisetum based diets for small holder farms.

## Introduction

Despite the huge livestock population in the country, productivity of animals in Ethiopia is lower than the regional and continental average. Among the factors contributing to low productivity, the low standard of feeding is the major one. Native pasture and crop residues provide the main source of nutrients for ruminants but these feed resources fail to meet the nutritional needs of livestock. Livestock suffer from seasonal fluctuation of feed quality and quantity.

To improve livestock production, sustainable solution to seasonal deficiencies in feed availability and quality are required. In the past, various forage species have been tested for their adaptability and yield potential across various agro-ecological zones. As a result promising species have been identified for agro-each ecological zone (Lulseged, 1989).

*Pennisetum purpureum* and its hybrids (*P.purpureum x P.typhoides*) are one of the promising grasses which adapt well in the medium and high land altitude of Ethiopia. With favorable environment napier forages usually grow quickly to maturity with concomitant reduction in quality. In a recent evaluation at Holetta, as a part of AFERNET collaborative work, it was observed that the pennisetum hybrids have a potential to provide high biomass yield of high quality forage. Thus, screening is needed to identify the best-bet accessions for further evaluation. Management strategy which optimize both quality and yield need to be identified for few selected lines to develop pennisetum based diet for small holders. The first part of this paper reports on results of initial screening to identify best bet lines and the second part deals on the effect of accession and cutting height on yield performances and nutritional quality selected pennisetum lines.

## Materials and methods

The study was carried out from August 1995 to July 1996 at the research fields of Institute of Agricultural Research, Holetta. The experimental site has an altitude of 2400 masl with annual rainfall of 1053 mm and it is characterized by bimodal rainfall distribution where 70 % of the rainfall is during the main rainy season (June to September) while the rest 30 % is during the small rainy season (February to April). The mean minimum and maximum temperatures of the site during the experimental period were 5.8°C and 22.6°C respectively. Frost occurs occasionally in the months of October to December as temperature below 0°c is recorded for some days during these months. The soils of the experimental site is characterized by Nitosol with a pH of 5.0, deficient in total nitrogen (0.12%) and available phosphorus (9.0 ppm)

Pennisetum hybrids (*P.purpureum x P.typhoides*) initially obtained from SADCC/ICRISAT through ILCA seed unit (gene bank) and each was planted in plots measuring 12 m x 1.35 m, randomized block design with three replications. Root splits of pennisetum were planted using spacing of 75 cm between rows, 2 m between blocks and 40 cm between plants on August 15, 1995. DAP at 100 kg/ha and urea at 50 kg/ha were applied at planting.

Cut for biomass yield were made at the end of the growing season and sub - samples were dried at 65°C for 48 h to estimate dry matter. Dry samples then were ground through 1 mm screen and analyzed for ash and CP (AOAC, 1980), neutral detergent fiber content (Georing and Van Soest, 1970), and *in vitro* organic matter digestibility (IVOMD) (Tilley and Terry, 1963). Frost tolerance ability of the lines were scored using 0-10 scales. The best-best accessions were selected based on yields of crude protein and digestible organic matter per ha and the selected lines were used for the second trial.

In trial 2, the effect of cutting height and accessions on biomass yield and quality were compared in a split plot design, where accessions were used as main plot

and cutting heights were used as sub-plot. Root splits of selected of pennisetum hybrids were planted on August 15, 1995. Spacing between rows and plants and rate of fertilizer applications were the same as described in trial 1. The forages were cut at 0.5 m, 1.0 m or 1.5 m and dried to estimate dry matter yield at each cutting height. Dried samples were then ground and analyzed for CP (AOAC, 1980), neutral detergent fiber content (Georing and Van Soest, 1970), and *in vitro* organic matter digestibility (IVOMD) (Tilley and Terry, 1963). Susceptibility to disease was assessed using scoring scale of 0-100 %. Rumen degradability characteristics of the accessions were evaluated by incubating a 3 gm feed sample that had been dried and then ground through a 2 mm screen, in a rumen fistula of three mature crossbred steers (540 sd= 40 kg) for 6, 12, 24, 48, 72 and 96 hours as described by Orskov *et al.*, (1980). After the bags were removed from the rumen they were washed and squeezed in running tap water until the water was colorless and then dried at 60°C for 48 h. The steers were fed grass hay *ad libitum* and noug cake (*Guizotia abysinica*) at the rate of 2 kg per head per day offered into two equal meals.

The *in situ* DM disappearances of forages were fitted to the equation of Ørskov and McDonad (1979). Differences in rate and extent of DM disappearances between the accessions were tested by parallel curve analysis (Ross, 1987).

## Results and discussion

Dry matter (DM) yields of pennisetum and pennisetum hybrid lines are given in Table 1. In the first harvest, DM yields of the tested lines varied from 0.7 - 2.2 t $ha^{-1}$ with a mean of 1.5 t $ha^{-1}$. The four hybrids which had higher DM yields were accessions 16835, 14984, 16786 and 16638 in a descending order. In the second cut which was after frost occurrence, productivity of the hybrids varied from 1.1 in accession 15743 to 7.2 t $ha^{-1}$ in accession 14984. With respect to plant height, accessions 16835, 16786, 16834 and 14984 had higher record than the mean height of all accessions.

In terms of frost tolerance, the accessions of pennisetum hybrids fall into three distinct groups. Accessions 16835, 16798 and 16638 were susceptible to frost (scale of< 5), accessions 16786, 15743, 16835 and local check had intermediate tolerance while accessions 16837, 16834 and 14984 had high tolerance (sore of> 8).

Chemical composition and *in vitro* digestibility of pennisetum lines are given in Table 2. The crude protein (CP) content of pennisetum and pennisetum hybrids varied from 13.3 to 17.0 % with a mean of 14.6%. Five accessions (15743, 16837, 16835, 16834 and 14984) had CP content of greater than 15% suggesting their adequacy to support animal production (milk, meat etc). Pennisetum hybrids had NDF content of 55 to 66% with a mean of 60%. The accessions tested in this study had NDF content above the threshold suggested to limit intake.

Table 1. Dry matter yield (t $ha^{-1}$), plant height and frost tolerance of pennisetum and pennisetum hybrid lines

| Accession | DM yield | | height | Frost |
|---|---|---|---|---|
| | cut1 | cut2 | CM | tolerance |
| Local | 0.9 | 3.3 | 81 | 7 |
| 16638 | 1.6 | 5.5 | 96 | 4 |
| 16798 | 1.4 | 4.7 | 93 | 3 |
| 16791 | 1.5 | 6.7 | 83 | 3 |
| 16786 | 1.9 | 3.5 | 110 | 6 |
| 16837 | 1.2 | 1.8 | 90 | 9 |
| 15743 | 0.7 | 1.1 | 55 | 6 |
| 16835 | 2.2 | 6.8 | 131 | 5 |
| 16834 | 1.4 | 6.1 | 108 | 10 |
| 14984 | 1.9 | 7.2 | 97 | 8 |
| Mean | 1.5 | 4.7 | 93 | 7 |
| LSD | 0.59 | 0.52 | 10.4 | |

Table 2. Chemical composition and *in vitro* DM digestibility, yields of crude protein yields and digestible organic matter (DOM) of pennisetum and pennisetum hybrids (on DM basis)

| Accession | CP | NDF | IVOMD | Yields (t/ha) | | Rank |
|---|---|---|---|---|---|---|
| | | | | CP | DOM | |
| Local | 13.7 | 58.2 | 67.0 | 0.20 | 1.14 | 9 |
| 16638 | 12.9 | 65.6 | 72.0 | 0.13 | 0.71 | 5 |
| 16798 | 13.8 | 63.2 | 70.4 | 0.19 | 1.02 | 7 |
| 16791 | 14.2 | 61.1 | 67.4 | 0.20 | 0.99 | 6 |
| 16786 | 13.3 | 61.7 | 71.9 | 0.25 | 1.40 | 3 |
| 16837 | 15.5 | 58.6 | 69.3 | 0.18 | 0.80 | 8 |
| 15743 | 17.0 | 55.0 | 72.4 | 0.12 | 0.53 | 10 |
| 16835 | 15.0 | 57.1 | 71.5 | 0.33 | 1.59 | 1 |
| 16834 | 15.1 | 60.1 | 68.8 | 0.21 | 0.99 | 4 |
| 14984 | 15.0 | 58.3 | 68.2 | 0.29 | 1.33 | 2 |
| Mean | 14.6 | 59.9 | 69.9 | | | |
| LSD | 0.41 | 0.73 | 0.20 | | | |

Dry matter yields of the pennisetum lines in this study was similar to the values reported for limited accessions under local condition (IAR, 1993). Chemical composition and digestibility values of napier grass in this study is in agreement with the values reported for some accessions of napier grass grown at ILRI, Ethiopia (Aninndo personal communication)

Based on biomass yields and nutritional quality, accessions 16835 was the best followed by accessions 14984, 16786 and 16834. These accessions were thus selected for further evaluations.

Dry matter yields of hybrids of pennisetum as affected by accession and cutting height are given in Table 3. The interaction term (cutting height by accession) had no significant effect on DM yields while each of the factors independently had a significant ($P < 0.01$) effect on yield performances of pennisetum. Across the three cutting heights, accession no 14984 was the best with a mean yield of 5 t DM $ha^{1}$ . Among the three cutting heights cutting at 1.0 m height out yielded the others. Four harvestable yields were obtained from the 0.5 m height cut at an interval of 7-8 weeks while at 1.0 height cut only two harvests were obtained.

The effect of accession and cutting height on chemical compositions and digestible DM of pennisetum hybrids are given in Table 5. Dry matter contents increased with increase in cutting height as plant maturity advances and the accessions tested had similar dry matter contents.

Table 3. The effect of accession and cutting height on annual yield performances of pennisetum hybrids (t DM \ha)

| | Cutting height (m) | | | Accession |
|---|---|---|---|---|
| Accession No | 0.5 | 1.0 | 1.5 | Mean |
| 14984 | 3.2 | 6.7 | 6.1 | 5.4 |
| 16786 | 2.8 | 4.8 | 3.0 | 3.5 |
| 16834 | 2.5 | 4.9 | 3.1 | 3.5 |
| 16835 | 4.0 | 4.3 | 4.5 | 4.3 |
| Cutting height mean | 3.15 | 5.19 | 4.20 | 4.17 |

Cutting height and accession number had no significant effect on ash content of pennisetum. Ash content had a tendency to decline with increase in cutting height. The ash contents of pennisetum in this study were similar to the results reported for pennisetum hybrids in Zimbabwe (Chakoma *et al*.1995) and this could be due to soil contamination. Both accession and cutting height had a significant ($P<0.5$) effect on CP content. Cutting at 0.5 m height resulted in the highest CP content (20.2%) while cutting at 1.5 m had the lowest (13.3%) and cutting at 1.0 m produced an intermediate CP level. The trend in CP content noted in this study is similar to the results reported by other authors where a decline in protein level has been reported as plant maturity advances (Shalaby *et.al*, 1991).

Table 5. The effect of accession and cutting height on chemical composition and *in vitro* DM digestibility of pennisetum hybrids

| | Cutting height | | | Accession |
|---|---|---|---|---|
| | 0.5 m | 1.0 m | 1.5 m | Mean |
| DM content (%) | | | | |
| 14984 | 18.9 | 19.9 | 20.3 | 19.7 |
| 16786 | 15.1 | 22.2 | 22.5 | 19.9 |
| 16834 | 17.9 | 20.7 | 21.1 | 19.9 |
| 16835 | 17.7 | 19.5 | 19.1 | 18.7 |
| Cutting height mean | 17.4 | 20.6 | 20.6 | 19.5 |
| Ash content (%) | | | | |
| 14984 | 16.9 | 15.6 | 15.4 | 15.9 |
| 16786 | 15.0 | 13.5 | 11.9 | 13.5 |
| 16834 | 14.7 | 14.7 | 13.6 | 14.3 |
| 16835 | 14.3 | 14.6 | 11.7 | 13.5 |
| Cutting height mean | 15.2 | 14.6 | 13.2 | 14.3 |
| Crude protein (%) | | | | |
| 14984 | 19.0 | 14.3 | 10.7 | 14.7 |
| 16786 | 17.7 | 13.1 | 10.7 | 13.8 |
| 16834 | 22.7 | 17.3 | 16.2 | 18.8 |
| 16835 | 21.2 | 16.2 | 15.7 | 17.7 |
| Cutting height mean | 20.2 | 15.3 | 13.3 | 16.2 |
| Neutral detergent fibre (%) | | | | |
| 14984 | 55.1 | 54.3 | 56.9 | 55.5 |
| 16786 | 58.9 | 54.3 | 62.4 | 58.5 |
| 16834 | 51.9 | 53.2 | 56.3 | 53.8 |
| 16835 | 55.4 | 54.3 | 59.3 | 56.3 |
| Cutting height mean | 55.3 | 54.0 | 58.7 | 56.0 |
| *In vitro* digestible DM (%) | | | | |
| 14984 | 71.3 | 70.7 | 61.4 | 67.8 |
| 16786 | 73.4 | 71.2 | 60.0 | 68.2 |
| 16834 | 76.5 | 72.7 | 56.1 | 68.4 |
| 16835 | 75.9 | 72.4 | 71.0 | 73.1 |
| Cutting height mean | 74.3 | 71.7 | 62.1 | 69.4 |

Neither accession nor cutting height had no significant effect on NDF content. Neutral detergent fiber content increased with increase in cutting height. Among accessions tested, accession 16786 was more fibrous (58.5%) while accession 16834 had the lowest fiber (53.8%). Cutting height on IVOMD of pennisetum is given in Table 5. Both factors had a significant effect on digestibility. As cutting height advances there was a decline in IVOMD of pennisetum though no substantial differences were noted among 0.5 and 1.0 m height of cuttings. Parameter estimates for rumen degradability characteristics of the accessions of pennisetum hybrids are given in Table 6. Analysis of variance to detect variation in parameter estimates and parallel curve analysis to detect pattern in degradability revealed that the accessions had similar rumen degradability characteristics. Though non significant, accession

16835 had higher rate of degradation than other accessions.

Table 6. Parameter estimates of dry matter degradability characteristics of the accessions of pennisetum hybrids cut at 1.0 m height

| Accession | a | b | a+b | c |
|---|---|---|---|---|
| 14984 | 23.5 | 58.2 | 81.7 | 0.0219 |
| 16786 | 27.4 | 58.8 | 86.2 | 0.0200 |
| 16834 | 20.8 | 64.7 | 85.5 | 0.0270 |
| 16835 | 19.4 | 59.8 | 79.2 | 0.0441 |
| Mean | 22.8 | 60.4 | 83.15 | 0.0283 |

Overall performances of pennisetum at 1.0 m height cut is given in Table 7. Among accessions tested, Accession number 14984 had the highest yield of CP and digestible organic matter followed by accession number 16834. Accession number 16786 was susceptible to diseases while accession number 16835 and 14984 were the best with regards to disease resistance.

As shown from the results of this study, some of the pennisetum hybrids can provide higher biomass yield and quality than pure pennisetum. Muldoon and Pearson (1977) reported that hybrid pennisetum have four agronomic advantages over annual species of pearl millet (*P. americanum*). These are perenniation, high yield, more management flexibility and low wastage. The hybrids combine the high yield and perennial nature of Pennisetum purpureum and with the high fodder quality of *P.americanum*.

Table 7. Variation in overall performance and disease resistance among hybrids of pennisetum harvested at 1.0 m height

| Accession No | CP $t\ ha^{-1}$ | DOM $t\ ha^{-1}$ | Disease score % |
|---|---|---|---|
| 14984 | 4.8 | 1.0 | 4.3 |
| 16786 | 3.5 | 0.6 | 11.7 |
| 16834 | 3.7 | 0.8 | 9.0 |
| 16835 | 3.3 | 0.7 | 3.7 |
| Mean | 3.8 | 1.0 | 7.2 |

Due to environmental variation between the different seasons, it is often necessary to determine of optimum stage of harvest of promising forages. In the present experiment, based on CP and digestible DM yield, cutting height of 1.0 m is appropriate to obtain better quality herbage. The research results of other workers also suggest that napier grass could be as a potential feed for cross bred cows if the grass is cut at 1.0 m height (Muinga *et. al*, 1992). Muinga *et.al*, (1992) evaluated the effect of harvest height (1.0 m and 1.5 m) of napier grass and level of leucanea supplement on total DM intake, live weight changes and milk yield of cross bred cows. Their result indicate that milk productions and intake were higher for cows fed napier grass harvested at 1.0 than cows fed 1.5 m. Further studies using intake and animal

performance trials are required to develop pennisetum based diets for small holder farms.

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# Feeding Value of *Leucaena leucocephala* and *Cajanus cajan* as Dry season Supplement for Kids

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## Abstract

A study was conducted to investigate the effect of browses (Cajanus and Leucaena) and concentrate supplementation on growth rate of rift-valley kids. A total of 32 (males and females) kids that weight 11.9 kg were allocated randomly to four dietary treatments(300 g Leucaena,300 g cajanus,200 g concentrate and no supplement group). Supplement rations were offered each day after eight hours grazing for 90 experimental days. Dietary treatments had significant effect ($p<0.05$) on weight gains of kids and sex differences were also significant ($p<0.01$). The over all result indicate that 300 g fresh leucaena or 300 g fresh Cajanus improve growth performances of kids.

## Introduction

Goats rank second to cattle in importance within the semi-arid mixed farming system of mid rift valley of Ethiopia (unpublished data, 1995). They are slaughtered for various social and religious purposes and sold in local market for cash income.

The major constraint which impedes productivity of goats is poor nutrition during the dry season, which extends from six to eight months in the mid-rift valley areas. During this period, the quality and quantity of feed resources decline and would not maintain the feed requirements of livestock (Lemma *et al.*, 1990).Most of the goats are kept under extensive management system and depend almost exclusively on natural pasture for their nutrient requirement. The availability of this feed resource is mainly determined by the amount of rainfall and length of the dry season in this area.

Previous work on the feeding system highland local goat and its cross with Sannen indicated that concentrate feeding has a significant effect on average daily live weight gain (Galal and Kassahun, 1981). However, feeding of concentrate is impractical in many areas of the country dominated by smallholder. The use of browses have been suggested as a strategy to improve nutritional status of small ruminant in the dry season. Fodder tree such as Leucaena and Cajanus have a great potential as a source of legume fodder and they could yield up to 5-8 tons of dry matter per/ha.per year. Among the numerous constraints limiting production in the extensive system of production, those related to poor nutrition are of primary concern.

To over come these constraints more research on the improvement of feeding is needed. This trial was conducted to assess feeding value of two browse species (*Leucaena leucocephala* and *Cajanus cajan*) as dry season supplementary feeds for kids.

## Materials and Methods

The trial was carried out at Adami Tullu livestock Research Center located at an altitude of 1650 km above sea level and had annual rainfall of less than 779 mm. Thirty two local (16 male and 16 female) kids which had average body weight of 11.9 kg and four to six months of age were used for the trail. The goats grazed together during the day time on natural vegetation around the center for eight hours each day. The major vegetation types of the area were pennesitum species, acacia, forbs and dwarf shrubs. After 8 hours grazing, in the late afternoon the kids were divided in to the following treatment groups.

Treatment 1 300 g fresh leucaena per kid/day
Treatment 2 300 g fresh cajanus per kid/day
Treatment 3 200 g concentrate per kid/day
Treatment 4 No supplement group.

The supplements were offered gradually by increasing the levels during adaptation period of one week. The type of concentrate used in this trial was composed of 59% maize grain, 40% noug cake and 1% salt. The kids were offered the supplements at full levels for 90 days and all had access to mineral licks. Feed offered and refusal were measured daily and body weight measurements were taken weekly during the trial. The live wight gains were calculated by regression and treatment were compared by analysis of variance using a model of randomized complete block design. Treatments means differences among the different treatments were separated by using Duncan's multiple range test.

## Results and Discussion

Chemical composition of the supplements used in the trial are shown in Table 1. All the supplements had crude protein content of greater than 18%. Cajanus was more fibrous than other supplements and had lower digestibility than others.

Table 1. Chemical composition of the supplement

| | Chemical composition(%DM) | | | | |
|---|---|---|---|---|---|
| Diet | DM | Ash | CP | NDF | ADF |
| Concentrate | 92.34 | 6.20 | 20.48 | 27.59 | 18.7 |
| Leucaena | 34.16 | 7.73 | 21.31 | 33.48 | 16.41 |
| Cajanus | 31.22 | 8.36 | 23.73 | 52.59 | 41.20 |

Source:Seyoum, 1995; Seyoum and Zinash,1989

Dietary treatments had significant effect ($p < 0.05$) on weight gains of kids (Table 2). Kids fed on concentrate and leucaenaand diets had higher growth ($P < 0.05$) growth rates than kids fed on either cajanus orpasture alone. Better responses to lecaeana supplementation could be due to its low fiber content compared to cajanus. Although there was response to supplementation, the control diet supported a reasonable level of gain indicating better quality of the basal diet during the trial period. Supplementary values of browses on this study is similar to the findings of Lemma and Alemu (1991). Mtenga and Madsen (1990) also reported that the growth rates of grazing lambs and kids improved from 30 to 60 g per day by use of daily supplement of 200 g concentrate containing 12 MJ ME/kg DM and 12-13% of digestible crude protein. In this experiment, males had higher average daily gain (65 g) than females (52 g) which is similar to the findings reported by Yebrah et al (1991) on yearling adal sheep fed on concentrate and leucaena under similar management condition.

Table 2. Body weights,average daily gains and dry matter supplement intake for the treatments

| | Body weighs (kg) | | Daily gain | Supplement |
|---|---|---|---|---|
| | initial | final | (g/day) | intake(g/day) |
| treatment | mean | mean | mean | mean |
| Concentrate | 12.00 | 17.10 | 63.60a | 136 |
| Leucaena | 11.87 | 17.20 | 62.20a | 130 |
| Cajanus | 11.90 | 16.72 | 58.80b | 128 |
| Control | 11.71 | 15.69 | 51.23c | - |
| F-test | | | | |
| Probability | | | $P < 0.05$ | |

Values within the column ,followed by the same letters are not significantly different ($p > 0.05$).

Among the two browses, leucaena supported live weight gains to a level which can be attained by concentrate feeding. This shows that the browse species can preferably be used as a dry season supplement to poor quality feeds. It is therefore concluded that supplements 300 g fresh Leucaena or 300 g fresh Cajanus during the dry season improve growth performances of kids.

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# Evaluation of Various Mathematical Models in Describing Ruminal Degradability of Protein Sources

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## Abstract

Five mathematical models were evaluated for their ability to describe ruminal degradability profiles of protein sources composed of herbaceous legumes, browse species and oilseed cakes. Degradability constants of dry matter, organic matter, nitrogen and neutral detergent fiber of the feeds were taken into account. Tests of regression coefficients, analysis of residual behavior and consistencies in parameter estimates were adopted for model comparison and validation. The conventional exponential model was the best for all feed classes in describing DM ,OM and N disappearance while the exponential decay model was the best in describing degradation profile of NDF for all feed classes.

## Introduction

Estimation of nutritive value of tropical feeds requires reliable technique which precisely predicts animal responses. The data base then can be used to set up goals for strategic utilization of the feed resources and optimization of animal production using the available resources. Tropical animal responses to diets formulated based on conventional feeding standards developed elsewhere (temperate conditions) have been noted to be far below expectation (Preston, 1982). The availability of nutrient availability in the tropical feeds to the animals may behave differently (Preston, 1982; Leng, 1985; Johnson and Pezo,1975).

Failures of the conventional feeding standards based on chemical analyses stem partly from their inability to take into account changes during rumen fermentation (Tamminga *et al.*, 1990). The data that accumulated from the quantitative digestion, metabolism and animal response in temperate condition have also led to much questioning of the dogma of feed evaluation and feeding standards as they are applied in practice especially for ruminants fed on poor quality roughage. Contemporary knowledge of ruminant nutrition clearly shows that the way toward substantial increases in productivity of ruminants on forage based diets is through an approach that balances nutrients and enhances the efficiency of the rumen ecosystem and the availability of nutrients post ruminally.

Thus, the concept of rumen degradability and digestion kinetics has become a focal point in feed evaluation.

One of the available techniques for evaluating rumen degradability of feeds is the nylon bag technique. Various mathematical models have been used to describe and interpret degradability patterns. The conventional model is the exponential model suggested by Orskov and Mc Donald (1979). Later Mc Donald (1981) modified the exponential model and included a discrete lag term for feeds which exhibit lag behavior. Mertens and Loften (1980) used log transformation of degradability data and recommended an exponential decay curve with undegradable fraction . In a comparison of various models, Robinson et al. (1986) suggested use of first order digestion kinetics model which includes potentially digestible fraction with its rate of digestion and undegradable component. Recently, Milgen et al.(1991) also suggested use of compartmental model for the analysis of nylon bag data. Unlike the other lag models with a discrete lag term, the compartmental model assumes that degradability occurs in two compartments: the lag compartment and digestion compartment each with its own rate of digestion.

Todate only few studies compared the various models (Robinson *et al.* 1986; Dhaona *et al.* 1988 and Milgen *et al.* 1991) and literally no studies have been made using tropical feeds. So far there is little or no information on degradation characteristics of local protein supplements and mathematical models which can best describe their degradation profiles are not known. This report compares 5 models with respect to fitness of ruminal degradability constants of dry matter (DM), organic matter (OM), nitrogen (N) and fiber (NDF) components of protein supplements.

## Materials and methods

### *Feedstuff, source and sampling sites*

The feedstuffs evaluated in this study included 18 samples of herbaceous legumes belonging to 11 genera, 18 samples of browse species belonging to 5 genera and 6 samples of oilseed cakes belonging to 6 genera. Herbaceous legumes and browse species were sampled from verification or advanced nursery plots of research centers at Holetta, Bako and Adamitulu. Oilseed cakes were sampled from the feed processing centers and oil seed meals around Addis Ababa.

### *Rumen degradability*

***Sample processing and analysis***. Fresh samples were dried at 60 °C in a forced draft oven for 72 hours. Dried samples were ground using 1 mm screen for chemical analysis and 2mm screen was used to grind samples for rumen degradability studies. Original and nylon bag residue samples were analyzed for dry matter, ash and crude protein (AOAC, 1980) and for neutral detergent fiber (Goering and Van Soest 1970).

***Experimental animals and their management***. Six ruminally cannulated mature crossbred steers (average body weight of 540 sd=40 kg) fed grass hay *ad libitum* and noug cake (2 kg per head per day in two equal meals) were used. The steers were kept in an individual tie stall and water was available at all times.

***Nylon bag incubation procedure***. Nylon bags of dimension 7.5 * 10.5 cm and porosity of 50 $\mu$m were used. About 3 g of feed was weighed per nylon bags. and two replicate bags were incubated per incubation period in the rumen of each steer for 2, 4, 8, 12, 16, 24, 36, 48, 72, 96, 120 h. Immediately after removal bags were placed in an ice bath to stop or minimize

bacterial activity and then rinsed with water until contents were clear. Bags were then rinsed individually by hand and dried at 60 °C for 48 h and hot weighted. Each residue was composted according to feedstuff and incubation time for subsequent analysis of DM, ash, N and NDF. The wash values were estimated by weighing 3 g of the test feeds in six bags and soaking in tape water and gently squeezing until contents were clear.

**Models and model evaluation**

Five different models (Table 1) were compared for their ability to describe ruminal degradability of DM, OM, N and NDF of the various protein sources. Degradation data were fitted to the models and the parameters estimates were generated for each sample using a non linear iterative procedure (NLIN) in the Statistical Analytical System (SAS, 1987) for models [1], [ 2] , [3] and [ 5]. Initial parameter estimates of model [3] were based on visual appraisal of data of each sample at a time. Model [4] was based on log transformation of the corrected residue (CRES) at each incubation time ;

CRES = R - IF

where R is residue during each incubation period and IF the 120 hour residue.

Models were ranked from best worst based on precision of residual standard deviation, serial correlation of residuals, regression coefficients and intercepts and consistencies in parameter estimates.

Table 1. Mathematical models tested in describing ruminal degradability of protein sources

| Item No | Model | Mathematical description | Source |
|---|---|---|---|
| 1 | Conventional | $P = a + b\,(1-e^{-ct})$ | Orskov and Mc Donald, 1979 |
| 2 | Lagged | $P = a + b\,(1- e^{-c(t- to)})$ | Mc Donald, 1981 |
| 3 | Compartmental | $R = \frac{b\,(c\,e^{-k1t} - e^{-ct}) + U}{(c- k1)}$ | Milgen *et al.*, 1991 |
| 4 | Log transformed | $R = (b * e^{-ct}) + U$ | Mertens and Loften , 1980 |
| 5 | Exponential decay * | $R = (b * e^{-ct}) + U$ | Robinson *et al.*, 1986 |

Where P = disappearance at time t
a = soluble fraction
b = Insoluble but degradable fraction
c = Rate constant for degradation
t = time of disappearance in hour
to = Lag time in hour
R = Residue left after time t
k1 = Rate constant for lag compartment
U = undegradable fraction
* Modified to include lag term for NDF disappearances

## Results and Discussion

### *Regression analysis*

Regression equation of predicted vs observed values of degradation profiles had highly significant adjusted $R^2$ . The mean adjusted $R^2$ were greater than 0.98 across models and feed classes. The various models evaluated in this study had similar $R^2$ and no distinction could be made between models using adjusted $R^2$ . The inadequacies of $R^2$ coefficients as a tool for comparing models have been demonstrated by Milgen *et al.*(1991) where sufficiently high $R^2$ ($>0.97$) were noted for various models while the regression coefficients and intercept varied significantly from unity and nil respectively. Tests of the regression coefficients and intercept revealed that the estimates of intercepts for some models (Table 2) significantly ($P< 0.05$) differed from nil while the slope also differed significantly ($P<0.05$) from unity . Model [1], [2], and [3] were more precise than model [4] or [5] for all feed classes and feed components. Model [4] was more precise in describing degradation profiles of browse species than the profiles of oil seed cakes and herbaceous legumes. Model [5] showed improvement in precision of regression coefficients and intercept when used for fitting ruminal degradabilities of fiber as opposed to DM, OM and N disappearances.

***Residual standard deviations***. The mean RSD of the models are given in Table 3 . Models [1], [2] and [3] had substantially lower RSD for all feed components and feed classes as opposed to the other models. Reported RSD for predicting *in vivo* digestibility from *in vitro* experiments (modified two stage Tilley and Terry,1963) are usually $< 2.00$. Using RSD of 2.00 as a threshold, models [1], [2] and [3] precisely estimated degradation profiles of all feed components. Model [4] was less precise especially for oilseed cakes while model [5] showed better precision for this class of feed. Model [5] had lower RSD for NDF disappearances than for the disappearances of DM,OM,and N of herbaceous legumes and oilseed cakes.

The low RSD of models [1], [2] and [3] indicate the adequacy of the first order kinetic equation in describing DM, OM and N disappearance of various protein sources. The inclusion of a discrete lag term [model 2] and lag compartment [model 3] showed no improvement in overall fit of the degradation profile. The fact that models [2] and [3] did not show improvement may indicate the absence of lag phase in the digestion of the feeds components understudy. As opposed to other components, NDF disappearance was better described by model [5] which could be due to absence of soluble fraction and inclusion of undegradable term in this model. This is in agreement with the suggestion of Robinson *et al.* (1986) and Fadel (1992).

***Serial correlation of residuals***. The mean serial correlation coefficients of residuals of the models are given in Table 4. Serial correlation coefficients were substantially low for models [1], [2], and [3] while models [4] and [5] had high coefficients. Significant serial correlation coefficients were noted for only few samples (0-17%) in models [1], [2], and [3] while models [4] and [5] had significant serial correlations for most (33-83 %) of the samples. The ranking positions indicated that models [1], [2], [3] were generally superior to models [4] and [5]. The position of model [4] relative to model [5] depended on the feed component and feed class. Among the feed

components, model [4] had the least performance for N followed by NDF while model [5] performed least for DM, OM and showed improvement for N and NDF.

The mean serial correlation coefficients of model [3] in this experiment was lower than serial correlation coefficients reported by Milgen et al (1991) for the same model. The mean serial correlation coefficients of models [1], [2] and [3] were negative and closer to zero while models [4] and [5] had positive serial correlation coefficients. Negative serial correlation coefficients indicate that successive values of the residuals change sign frequently (sawtooth pattern) and there was no continuous under or over prediction of the degradation profile. The positive serial correlation coefficients indicate that the residuals do not change sign frequently so that several positive residuals are followed by several negative residuals. This in turn indicates that there was a continuous under prediction and over prediction of the degradation profile. Significant serial correlation coefficients of the residuals suggest that the residuals of some models were not randomly distributed and the models had systematic bias in representing true relationship. In this experiment no systematic deviations were noted for model [1] in describing DM, OM and N disappearance of protein sources which could be due to absence of lag phase.

***Consistencies of the models***. The mean coefficients of variation of the models in estimating the rate constant" C" are given in Table 5. With the exception of model [4] all the tested models had low CV for all feed components and feed classes. Among the feed components studied, N degradation rate had the highest CV which could be due to variation in microbial contamination. NDF degradation rate had the least CV. In terms of consistency model [5] was the best and it had the first ranking position especially for NDF, N and OM.

The values for CV of the models in this study was substantially lower than the values reported by various authors for protein sources. In describing N disappearances of herbaceous legumes Abule (1994) reported CV of 5-23 % for OM and 5-14 % for N disappearances using the same model. Saiw *et al.* (1993) also reported EMS of 21-167 for DM disappearances of browse. The mean CV of model [5] in describing NDF disappearances of protein sources was similar to the mean CV of the same model reported by Robinson *et al.*(1986).

***Over all performance of models and final ranking***. Taking in to consideration the ranking position of the models for each set of criteria the total rank and average rank of the models are given in Table 6. Models [1] and [2] were ranked best or first for all feed classes and feed components followed in order by models [3], [5] and [4].

When the ranking positions are changed to values and weighted for differences in mean CV for the rate constant (Table 6) models [1] and [2] still performed best for DM, OM and N components of the various protein sources. Model [5] was the best model in describing degradation profile of NDF. Comparison between models [1] and [2] for each set of criteria considered suggested that there was little to choose among the two models. Thus, model [1] was considered as the best model in describing ruminal degradability of DM, OM and N while model [5] was the best model for NDF disappearances of the various protein sources.

Comparison of mathematical models is often precluded by lack of a standard procedure to be used in model testing. Mertens and Loften (1980) used R-square and RSD while Milgen *et al*. (1991) used residual mean square (RMS), $R^2$ and prediction sum of square. Robinson *et al.*, (1986) also used residuals and coefficient of variation (CV). Beuvink and Kogut (1993) have also used RMS in testing models for gas production kinetics of silage.For a similar purpose Fadel (1992) used $R^2$ and determinant of the inverse-covariance matrix to evaluate sampling schedule design for ruminal degradability of fiber.

In the present study tests of regression coefficients, analysis of residual behavior and consistencies in parameter estimates were adopted for model comparison and validation. Using these criteria, model[1] was the best in describing DM , OM and N degradation profile while model [5] was the best in describing fiber disappearances. Model [4] performed worst for most of the feed classes and feed components. Poor precision of log transformed data have also been noted by Mertens and Loften (1980) and Milgen *et al.*(1991) in describing dry matter disappearance. Milgen *et al.* (1991) noted no relationship between the variance and the mean response of replicate observations of rumen degradability for various feed classes and suggested that the variance might be destabilized in the absence of this relationship. According to Fisher *et al.* (1989) log transformation introduces a strong bias by weighing deviations at the later stage of fermentation more heavily than at early or mid stages and this error is more serious if the fraction being modeled is a rapid degrading one. Thus, model 4 performed worst than the other models in describing DM, OM , N and NDF disappearances of protein sources. As suggested by regression analysis, model [4] was worst for rapid degrading component (N) than for slow degrading component (NDF).

The exponential model [model 1] is widely used in ruminant feedstuffs evaluation to describe degradation kinetics as measured by the nylon bag technique (Orskov and Mc Donald, 1979) but it has also been used to describe kinetic of gas production (Krishnamoorthy, 1983). Beauvink and Kogut (1993) reported that the fit of exponential model to gas production was inferior to the other sigmoid models and proposed a modified Gomptez equation. From mathematical or statistical point of view the exponential model (Orskov and Mc Donald, 1979) is within the permissible error of closure in describing degradation profile of feeds. However, the assumption of homogeneity of the insoluble but degradable fraction is far from reality. Kempton et al (1980) also identified two digestible pools each with its own rate of digestion for barley. In the present study the exponential model (Orskov and Mc donald, 1979) adequately described the degradation profile of DM, OM and N components of the feeds. Based on model testing and validation procedure used in this study, the exponential model of Orskov and Mc Donald (1979) was the best in describing degradation profile of DM, OM and N of local protein sources. The exponential decay model (Robinson *et al.*, (1986) with undegradable fraction was the best in describing NDF disappearances of the feeds.

Table 2. Tests of regression coefficients and model rank

| Feed component | Feed class | Samples with no significant Intercept* | | | | | Sample with no Significant Slope* | | | | | Model rank | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| DM | 1 | 100 | 100 | 100 | 60 | 20 | 100 | 100 | 100 | 67 | 29 | 1 | 1 | 1 | 2 | 3 |
| | 2 | 100 | 100 | 100 | 88 | 44 | 100 | 100 | 100 | 88 | 19 | 1 | 1 | 1 | 2 | 3 |
| | 3 | 100 | 100 | 100 | 33 | 17 | 100 | 100 | 100 | 33 | 33 | 1 | 1 | 1 | 2 | 3 |
| OM | 1 | 100 | 100 | 100 | 60 | 34 | 100 | 100 | 100 | 65 | 25 | 1 | 1 | 1 | 2 | 3 |
| | 2 | 100 | 100 | 100 | 88 | 56 | 100 | 100 | 100 | 81 | 63 | 1 | 1 | 1 | 2 | 3 |
| | 3 | 100 | 100 | 100 | 67 | 33 | 100 | 100 | 100 | 67 | 50 | 1 | 1 | 1 | 2 | 3 |
| N | 1 | 100 | 100 | 100 | 60 | 20 | 100 | 100 | 100 | 45 | 35 | 1 | 1 | 1 | 2 | 3 |
| | 2 | 100 | 100 | 100 | 88 | 50 | 100 | 100 | 100 | 75 | 50 | 1 | 1 | 1 | 2 | 3 |
| | 3 | 100 | 100 | 100 | 67 | 33 | 100 | 100 | 100 | 33 | 67 | 1 | 1 | 1 | 2 | 3 |
| NDF | 1 | 100 | 100 | 100 | 75 | 75 | 100 | 100 | 100 | 75 | 100 | 1 | 1 | 1 | 2 | 3 |
| | 2 | 100 | 100 | 100 | 88 | 44 | 100 | 100 | 100 | 100 | 100 | 1 | 1 | 1 | 2 | 3 |
| | 3 | 100 | 100 | 100 | 83 | 83 | 100 | 100 | 100 | 83 | 100 | 1 | 1 | 1 | 2 | 3 |

* Proportion of samples whose intercept do not significantly differ from 0 (expressed as percentage of total samples evaluated)
** Proportion of samples whose slope do not significantly differ from 1 (expressed as percentage of total samples evaluated)

Table 3. Residual standard deviations of the models and model rank

| Feed component | Feed class | Mean RSD of the models | | | | | Samples with RSD of less than 2.0* | | | | | Model rank | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| DM | 1 | 0.55 | 0.55 | 0.59 | 1.30 | 1.65 | 100 | 100 | 100 | 80 | 75 | 1 | 1 | 2 | 3 | 4 |
| | 2 | 0.65 | 0.63 | 0.67 | 1.20 | 1.59 | 100 | 100 | 100 | 88 | 94 | 1 | 1 | 2 | 4 | 3 |
| | 3 | 0.39 | 0.39 | 0.41 | 1.94 | 1.47 | 100 | 100 | 100 | 67 | 83 | 1 | 1 | 2 | 4 | 3 |
| OM | 1 | 0.28 | 0.28 | 0.30 | 0.67 | 1.05 | 100 | 100 | 100 | 100 | 95 | 1 | 1 | 2 | 3 | 4 |
| | 2 | 0.70 | 0.70 | 0.75 | 1.20 | 1.23 | 100 | 100 | 87 | 81 | 81 | 1 | 1 | 2 | 3 | 4 |
| | 3 | 0.69 | 0.69 | 0.72 | 1.58 | 1.28 | 100 | 100 | 100 | 50 | 100 | 1 | 1 | 3 | 4 | 2 |
| N | 1 | 0.41 | 0.41 | 0.47 | 1.04 | 1.05 | 100 | 100 | 100 | 95 | 95 | 1 | 1 | 2 | 3 | 4 |
| | 2 | 0.68 | 0.68 | 0.67 | 1.29 | 1.13 | 94 | 94 | 94 | 81 | 88 | 1 | 1 | 2 | 4 | 3 |
| | 3 | 0.68 | 0.68 | 0.75 | 1.20 | 1.26 | 100 | 100 | 100 | 83 | 83 | 1 | 1 | 3 | 3 | 4 |
| NDF | 1 | 0.56 | 0.59 | 0.47 | 1.42 | 0.84 | 100 | 100 | 100 | 95 | 85 | 2 | 2 | 1 | 4 | 3 |
| | 2 | 0.56 | 0.59 | 0.50 | 1.84 | 1.35 | 100 | 100 | 100 | 50 | 69 | 2 | 2 | 1 | 4 | 3 |
| | 3 | 0.63 | 0.67 | 0.64 | 2.03 | 0.85 | 100 | 100 | 100 | 67 | 100 | 1 | 2 | 3 | 5 | 4 |

* Proportion of samples expressed as percentage of total samples evaluated

Table 4. The mean serial correlation coefficients of the residuals of each model

| Feed component | Feed class | Mean serial correlation coefficient | | | | | Sample with no significant serial correlation* | | | | | Model rank | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| DM | 1 | -0.04 | -0.04 | -0.04 | 0.46 | 0.67 | 100 | 100 | 100 | 60 | 25 | 1 | 1 | 1 | 2 | 3 |
| | 2 | -0.15 | -0.15 | -0.15 | 0.41 | 0.75 | 94 | 94 | 94 | 56 | 25 | 1 | 1 | 1 | 2 | 3 |
| | 3 | -0.04 | -0.04 | -0.04 | 0.77 | 0.74 | 100 | 100 | 100 | 17 | 33 | 1 | 1 | 1 | 3 | 2 |
| OM | 1 | -0.13 | -0.13 | 0.17 | 0.55 | 0.70 | 95 | 95 | 90 | 35 | 35 | 1 | 1 | 2 | 3 | 4 |
| | 2 | -0.19 | -0.19 | -0.10 | 0.56 | 0.61 | 100 | 100 | 100 | 56 | 25 | 2 | 2 | 1 | 3 | 4 |
| | 3 | -0.28 | -0.28 | -0.27 | 0.57 | 0.50 | 100 | 100 | 67 | 67 | 33 | 1 | 1 | 2 | 3 | 4 |
| N | 1 | -0.10 | -0.10 | -0.02 | 0.56 | 0.70 | 100 | 100 | 85 | 35 | 35 | 1 | 1 | 2 | 3 | 4 |
| | 2 | -0.05 | -0.05 | -0.09 | 0.63 | 0.62 | 100 | 100 | 100 | 31 | 38 | 1 | 1 | 2 | 4 | 3 |
| | 3 | -0.24 | -0.24 | -0.14 | 0.43 | 0.54 | 83 | 83 | 83 | 33 | 83 | 2 | 2 | 1 | 4 | 3 |
| NDF | 1 | -0.06 | -0.06 | 0.15 | 0.60 | 0.30 | 100 | 100 | 90 | 35 | 50 | 1 | 1 | 2 | 4 | 3 |
| | 2 | -0.07 | -0.07 | 0.23 | 0.68 | 0.61 | 100 | 100 | 94 | 44 | 25 | 1 | 1 | 2 | 3 | 4 |
| | 3 | 0.14 | 0.14 | -0.22 | 0.55 | 0.18 | 83 | 83 | 83 | 50 | 67 | 1 | 1 | 2 | 3 | 4 |

* proportion of samples expressed as percentage of total samples evaluated

Table 5. Consistencies of the models in estimating the rate constant "c"

| Feed component | Feed class | Mean CV for the models | | | | | Sample with CV of less than 10% | | | | | Model rank | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| DM | 1 | 3.17 | 3.17 | 3.16 | 8.07 | 3.27 | 100 | 100 | 100 | 75 | 100 | 2 | 2 | 1 | 4 | 3 |
| | 2 | 3.90 | 3.90 | 3.89 | 5.91 | 3.14 | 100 | 100 | 100 | 94 | 100 | 3 | 3 | 2 | 4 | 1 |
| | 3 | 3.76 | 3.76 | 3.76 | 11.11 | 3.34 | 100 | 100 | 100 | 50 | 100 | 2 | 2 | 2 | 3 | 1 |
| OM | 1 | 3.04 | 3.04 | 4.31 | 7.88 | 3.04 | 100 | 95 | 90 | 75 | 100 | 2 | 2 | 3 | 4 | 1 |
| | 2 | 3.92 | 3.92 | 5.58 | 5.63 | 2.83 | 94 | 100 | 100 | 88 | 100 | 4 | 1 | 3 | 5 | 2 |
| | 3 | 4.12 | 4.12 | 4.44 | 10.84 | 3.49 | 100 | 100 | 100 | 50 | 100 | 3 | 1 | 4 | 5 | 2 |
| N | 1 | 4.41 | 4.41 | 6.49 | 10.08 | 4.32 | 90 | 90 | 85 | 60 | 95 | 3 | 2 | 4 | 5 | 1 |
| | 2 | 4.16 | 4.16 | 4.41 | 6.00 | 2.74 | 100 | 100 | 100 | 88 | 100 | 3 | 2 | 4 | 5 | 1 |
| | 3 | 6.67 | 6.67 | 5.88 | 11.64 | 5.70 | 83 | 83 | 83 | 50 | 88 | 4 | 3 | 2 | 5 | 1 |
| NDF | 1 | 2.55 | 2.55 | 3.60 | 4.92 | 1.76 | 95 | 95 | 90 | 90 | 100 | 3 | 2 | 4 | 5 | 1 |
| | 2 | 1.77 | 1.77 | 2.24 | 2.16 | 1.26 | 100 | 100 | 100 | 100 | 100 | 3 | 2 | 5 | 4 | 1 |
| | 3 | 2.25 | 2.25 | 2.93 | 8.46 | 2.16 | 100 | 100 | 100 | 83 | 100 | 3 | 2 | 4 | 5 | 1 |

Table 6. Value of ranking positions and final ranking of models weighted for CV of rate constant "C"

| Feed component | Feed class | Value of ranking positions | | | | | Value of ranking weighted for "C" | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| DM | 1 | 3.75 | 3.75 | 3.75 | 2.75 | 1.75 | 1.18 | 1.18 | 1.19 | 0.34 | 0.54 |
| | 2 | 3.50 | 3.50 | 3.50 | 2.00 | 2.50 | 0.90 | 0.90 | 0.90 | 0.34 | 0.80 |
| | 3 | 3.75 | 3.75 | 2.50 | 2.00 | 2.75 | 1.00 | 1.00 | 0.66 | 0.18 | 0.82 |
| OM | 1 | 3.75 | 3.75 | 3.00 | 2.00 | 2.00 | 1.23 | 1.23 | 0.70 | 0.25 | 0.66 |
| | 2 | 3.50 | 3.50 | 3.25 | 2.00 | 2.00 | 0.89 | 0.89 | 0.58 | 0.36 | 0.71 |
| | 3 | 3.75 | 3.75 | 3.00 | 1.50 | 2.50 | 0.90 | 0.90 | 0.62 | 0.16 | 0.72 |
| N | 1 | 3.75 | 3.75 | 3.00 | 2.00 | 2.00 | 0.85 | 0.85 | 0.46 | 0.20 | 0.46 |
| | 2 | 3.75 | 3.75 | 3.00 | 1.50 | 2.50 | 0.90 | 0.90 | 0.68 | 0.25 | 0.91 |
| | 3 | 3.25 | 3.25 | 3.25 | 1.75 | 2.25 | 0.49 | 0.49 | 0.55 | 0.15 | 0.39 |
| NDF | 1 | 3.50 | 3.40 | 3.00 | 1.20 | 3.00 | 1.37 | 1.33 | 0.83 | 0.24 | 1.70 |
| | 2 | 3.50 | 3.50 | 2.60 | 2.20 | 3.40 | 1.98 | 1.98 | 1.16 | 1.01 | 2.70 |
| | 3 | 3.50 | 3.50 | 2.80 | 1.00 | 2.80 | 1.56 | 1.56 | 0.96 | 0.12 | 1.30 |

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# Observation on Potential of Various Treatment Options to Overcome the Inhibition Of Germination in Tagasaste (*Chamaecytisus palmensis*)

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## Abstract

Untreated tagasaste seeds usually germinate at low rates (2-5%) and slowly as a result of dormancy due to impermeable hard seed coat. Wet heat using boiling water, dry heat using an oven temperatures of 45, 55, 65, 75, 85 and 105°C, hot plate, and sand paper scarification of tagasaste seed for different length of time were tested to break dormancy of Tagasate. Germination trial of treated seeds was conducted at Holetta research centre in a randomized block design. Soil media under field condition and bloating paper media in the laboratory at room temperature were used for germination. Scarification improved germination significantly while boiling water treatment for 7-11 minutes resulted up to 75% germination. Dry heat treatment up to 85°C and sand paper scarification gave germination up to 40% and dry heat treatment at 105°C even for shorter periods, 1 hour and hot plat treatments (half a minute) resulted in complete loss of viability.

## Introduction

Tagasaste commonly called tree lucerne is a hardy leguminous shrub originated in the Canary Islands (Snook, 1982; Hawley, 1984; and Townsend and Radcliffe, 1990). It is well adapted and widely distributed in the highlands of Ethiopia over 2400 m above see level (Lazier, 1987; Ministry of Agriculture, 1989; and Getnet, 1991). Tagasaste can be established from transplanting of seedlings, through direct seeding and some times from stem cuttings. Preliminary observations on tagasaste establishment methods at Holetta showed higher percentage from transplanting of seedlings (82%) than direct seeding (26%) and stem cuttings (3%) (IAR, 1989 - 1994). Direct seeding is cheaper and appropriate means of establishing tagasaste in the highland farming system of Ethiopia. However, in cold relatively wet soil and sever weed competition conditions, transplanting seedlings is beneficial than direct seeding.

Tagasaste produce high amount of quality seed. At Holetta, it produces 315 g of mature seeds per tree per year (IAR, 1989-1994). The seeds have hard coats which is impermeable and needs treatment. Hawley (1984) indicated that seeds without treatment germinate only 3-4 % while boiling water treatment increased germination to 60-70%. At Holetta, observation indicate that untreated seeds gave a negligible germination while boiling water treatment for about 7 minutes enhanced germination. Therefore seed treatment is a prerequisite for tagasaste establishment. Hence applying appropriate seed treating practices and methods is of paramount importance.

Seeds with hard seed coats can be treated by use of chemicals, heat (dry or wet) and mechanically treatment. The convenience and cost of each method may be relevant for the particular area and production system so as one can choose the appropriate method accordingly (Ellis *et al.*, 1985).

Under Ethiopia condition, chemical treatments are not feasible and not appropriate, however, dry heat , wet heat and mechanical treatments could be cheaper and easy to practice. While treating seed with these methods precise and optimum treating procedures should be established to attain the desired establishment. Hence one should identify the type of treatment, the length of treating time and the procedure of treatment to optimize germination. Information in this line is scarce and scanty. This paper reports the potential of different scarification methods and identify optimum length of treating time of tagasaste seeds to break dormancy of tagasaste.

## Materials and Methods

The experiment was conducted at Holetta Research Centre from March to June, 1996 under field and laboratory condition. The area is located at 2400 m altitude and receives an annual rainfall of 1100 mm. Matured tagasaste seeds which were collected at Holetta and stored for two years in a relatively cold room (< 20°C) were used for this experiment.

Table 1. Seed treatment methods and their respective length of treating time

| Treating Methods | Length of treating time |
|---|---|
| Dry heat 45°C (Oven) | 6, 12, 18, 24, 36, 48, 64, and 72 hours |
| Dry heat 55°C (Oven) | 6, 12, 18, 24, 36, 48, 64, and 72 hours |
| Dry heat 65°C (Oven) | 6, 12, 18, 24, 36, 48, 64, and 72 hours |
| Dry heat 75°C (Oven) | 6, 12, 18, 24, 36, 48, 64, and 72 hours |
| Dry heat 85°C (Oven) | 1, 3, 6, 9, 12, 15, 18, 21, and 24 hours |
| Dry heat 105°C (Oven) | 1, 3, 6, 9, 12, 15, 18, 21, and 24 hours |
| Wet heat (Boiling water) | 1, 3, 5, 7, 9, 11, 13, 15, 20 and 30 minutes |
| Hot plate ("Mitad") | 0.5, 1, 1.5, 2, 2.5, 3, 3.5 and 4 minutes |
| Sand Paper | 1, 3, 5, 8, and 10 minutes |

Scarification procedure: 50 g seed was prepared for each treatment and scarified accordingly as follows.

- For all the oven heat treatments seeds were kept in thin paper envelops and allowed to stay for different length of periods in a forced draft oven adjusted to the above indicated temperatures in table 1.

- Wet heat treatment was done using boiling water where seeds were soaked in boiling water (92°C) and stayed for 1-30 minutes according to the treatment. The

boiled seeds were poured in to a cloth bag and immersed in a cold tap water for few minutes and allowed to sun dry.

- A local made pan used for baking injera ("Mitad") was used as a hot plate for treating the seeds. The seeds were poured on the hot pan for different length of time according to the treatment. While treating, the seeds were continuously disturbed.

- Hand scarification of seeds using sand paper (one sand paper at the bottom and the other at the top) were done for 1, 3, 5, 8 and 10 minutes continuously.

Each seed treatment method was tested separately in a randomized block design with four replications under laboratory and field condition. The treatments were the respective length of treating time in each seed treatment method.

In the laboratory 50 seeds from each treatment (length of treating time) were used in a replication. Seeds were allowed to germinate in a petridish using bloating paper media under room temperature (17- 22°C).

Under field condition forest soil, sand, and manure in 2:1:1 proportion were mixed and filled in plastic pots. Twenty five seeds from each treatment were sown in 5 pots (5 seeds per pot) per replication. Untreated tagasaste seeds were included in all seed treatment methods as a control. Both the field and laboratory experiments were done at the same time. Watering and seedling count were done every three days. Counting of seedlings was continued for the following 10 weeks.

## Results and Discussion

Germination of tagasaste seeds was tremendously improved by the different seed treating methods. Boiling water and oven heat (at 85°C) treatments highly improved germination. Untreated seeds (control) were almost failed to germinate (<2%) both under field and laboratory conditions.

Among the various methods tested, boiling water treatment was found to be the best method. Table 2 shows the percentage of seed germinated at different length of time treated with boiling water. Treating for one minute gave an average germination of 52% and consistently increased up to 9 minutes giving 65 % and declined then after. Treating one to two hours using oven heat at 85°C gave 43 - 45% germination. It declines as the treating time increased up to 24 hours, however, compared to the control still longer treating hours also gave higher germination rates (Table 3).

In both boiling water and oven heat (85°C) treatments, germination was higher when tested under laboratory conditions by 55 and 12 % respectively. This might be due to the controlled environment and appropriate management used for germination in the laboratory. Nevertheless, the potential germination expected should still be higher than what is recorded. Because the germination in the laboratory is done at room temperature. But given the ideal environment for germination like using germination chambers, the germination percentage could be higher (Ellis *et al.*, 1985).

Table 2. Percent of Tagasaste seeds germinated at different length of seed treating time using boiling water under laboratory and field conditions.

| Length of treating time (minutes) | Media | | Mean |
|---|---|---|---|
| | Soil (Field) | Bloating paper (Laboratory) | |
| 1 | 40.5 | 63.5 | 52.0 |
| 3 | 55.0 | 68.5 | 61.8 |
| 5 | 51.0 | 74.5 | 62.8 |
| 7 | 50.0 | 76.5 | 63.3 |
| 9 | 49.0 | 80.5 | 64.8 |
| 11 | 37.0 | 68.5 | 52.8 |
| 13 | 41.0 | 63.0 | 52.0 |
| 15 | 34.0 | 67.5 | 50.8 |
| 20 | 35.0 | 55.5 | 45.3 |
| 30 | 22.0 | 28.5 | 25.3 |
| control | 2.0 | 1.5 | 2.3 |
| Mean | 38.0 | 58.9 | 48.4 |
| Lsd (0.05) | 12.9 | 12.5 | 9.0 |

Table 3. Percent of Tagasaste seeds germinated at different length of seed treating time using an oven at 85°C under laboratory and field conditions.

| Length of treating time (hours) | Media | | Mean |
|---|---|---|---|
| | Soil (Field) | Bloating paper (Laboratory) | |
| 1 | 40.0 | 49.5 | 44.8 |
| 2 | 40.0 | 45.5 | 42.8 |
| 3 | 29.0 | 44.0 | 36.5 |
| 6 | 36.0 | 33.0 | 34.5 |
| 9 | 32.0 | 45.0 | 38.5 |
| 12 | 34.0 | 33.5 | 33.8 |
| 15 | 36.0 | 34.5 | 35.3 |
| 18 | 31.0 | 47.0 | 39.0 |
| 21 | 29.0 | 36.0 | 32.5 |
| 24 | 34.0 | 15.5 | 24.8 |
| Control | 2.0 | 0.5 | 1.3 |
| Mean | 31.2 | 34.9 | 33.1 |
| Lsd (0.05) | 15.8 | 14.0 | 10.6 |

Obtaining a synchronized uniform size and age of seedlings is one of the desired qualities in nurseries. The method and length of time during seed treatment influenced the number of seeds germinated during the specified range of time starting from sowing which in turn affect the uniformity in size and age of seedlings. In addition to higher percent of germination obtained by boiling water treatment, it is also clearly seen that the majority of seeds germinated during the second to third week after sowing, this has the advantage of getting similar size seedlings. Shorter treating time showed extended period of time for germination with variable seedling size while longer treating times resulted in higher in germination in short period of time with uniform size but lower number of seedlings (Fig. 1a). Oven heat treatment at 85°C as indicated in Fig. 1b, gave lower total percentage of germination over an extended period of time compared to boiling water treatment. Boiling water treatment for 9 -11 minutes gave higher and uniform seedlings. From the total seed germinated more than 70 % germinated during the second and third week and the remaining during the fourth week.

Fig 2a and 2b shows the percentage of germination of seeds at different temperature and length of treating time under field (soil media) and in the laboratory (bloating paper media) condition respectively. Longer periods (6 - 72 hours) at 45, 55, 65 and 75°C gave significantly higher germination over the control. At 45 and 55°C germination was relatively lower which on average ranged from 0.5 - 16.5 % and 0.5 - 24.5 % respectively. Generally as the temperature increases from 45 to 65°C the average total germination also increased. Similarly in each temperature treatment the germination percentage increased consistently as the treating time increased from 6 to 72 hours. However at 75°C germination percentage showed a sharp increase up to 18 hours treatment but declined then after. This indicates that longer treating hours ($>18$) above 75°C might cause loss of seed viability.

Hand scarification of 50 g of seed up to 10 minutes using sand paper improved germination up to 20 %. This was found not satisfactory even if it was better than the control. Ten minutes scarification for 50 g of seed was not adequate enough to get higher germination and longer time of scarification is required.

Treating seeds for an hour at 105°C and for half a minute using hot plates resulted in a complete loss of seed viability. All the seeds treated using these methods at different length of time failed to germinate both under field and laboratory conditions suggesting that shorter treating periods are required than what have been tested for this method.

Seed dormancy is the major problem in forage crops specially in browses and legumes like tagasaste and clovers. Seed treating methods for promising forage crops are very helpful for successful pasture establishment and efficient utilization of seeds which are very expensive in the world market. From this experiment it was confirmed that 7-11 minute boiling water treatment was the best and convenient method of tagasaste seed scarification for higher percent and uniform size and aged seedlings over short period of time. Oven heat treatment for 1-3 hours at 85°C could also be an alternative seed scarification method.

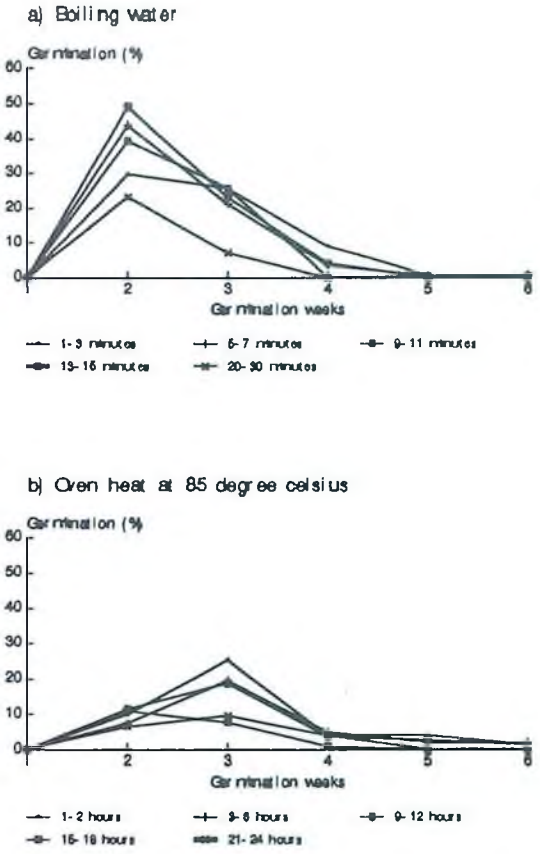


Fig 1. Effect of length of seed treating time on the number of seeds germinated and date of germination under laboratory condition in tagasaste when treated using a) boiling water and b) oven heat at 85°C.

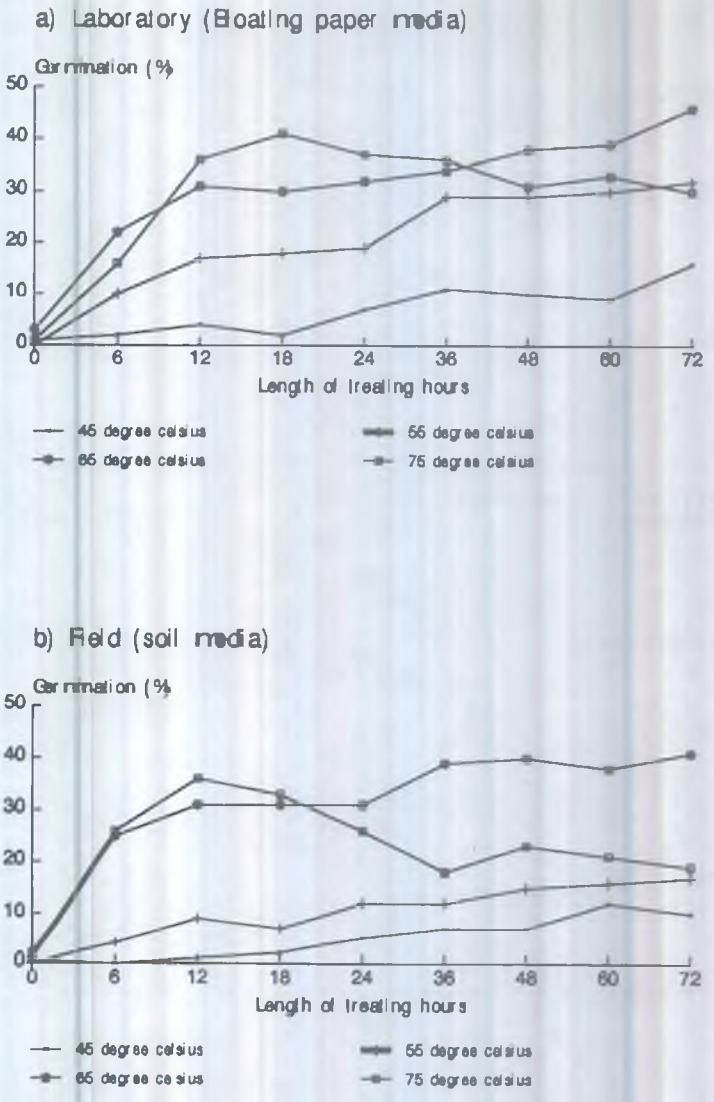


Fig 2. Effect of different oven temperature treatments and length of treating time on germination of tagasaste seeds under a) laboratory and b) field condition.

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# The Effect of Molasses Urea Block and Concentrate Supplementation On Growth Rate of Arsi Bulls

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## Abstract

A 120 days feeding trial was conducted to study the supplementary value of Urea Molasses Block (UMB) and different levels of concentrate on growth performance of Arsi bulls. A total of thirty Arsi growing bulls with initial body weight of 129 kg were used to test five treatments: grazing (G), G+urea molasses block (UMB) ad-libitum, G + UMB + 0.5Kg concentrate/h/d, G+UMB+1Kg concentrate /h/d, G+UMB+2Kg concentrate /h/d. All experimental animals gained body weight. Total supplement intake increased as the level of concentrate increased. Supplementing grazing animals with UMB improved their growth rate ($p<0.05$). Supplementing UMB with concentrate reduced the UMB intake. Adding more concentrate reduced ($p<0.05$) UMB intake and it increased ($P<0.05$) the growth rate. Gain per DMI was highest ($P<0.05$) in treatment 2 (animals supplemented with UMB only). Cost of supplement per unit of gain was lower ($P<0.05$) in treatment 2 than other groups and Supplementing UMB with concentrate is not economical. Future strategies to support better growth performance of Arsi bulls should focus on mechanisms to improve intake of molasses urea block.

## Introduction

Native pasture produce young growth of fair quality early in the growing season, but as they mature feeding value falls rapidly. In particular native pastures of mid rift valley become markedly deficient in protein and energy. The botanical composition of the natural pasture indicates grasses are the dominant cover of Adami Tulu area of which *Pennisetum stramineum* has got the largest share (86.8%). Legumes are found in a small quantity (3.93%). The Legume proportion in relation to the grasses is an indication of poor pasture quality in its nitrogen content. There fore supplementation of this pasture with unconventional and cheap source of energy and fermentable NPN as well as by-pass protein becomes essential.

It is known that diets with less than 7% crude protein are not readily eaten by ruminants. An inadequate supply of N will retard microbial growth and there by impede the degradation of cell wall components (Trung, 1986). Rumen ammonia concentrations of 2-5 mg/100 ml are considered adequate for rumen microbial synthesis and activity (Devendra, 1975).

To attain these N levels, a diet should contain 11-14% CP (or 2%N). The low N content of fast growing and early maturing tropical pastures limit fermentation in the rumen, hence feed intake. Urea which is a readily fermentable NPN, stimulates the intake of these low quality roughage and increases fermentation in the rumen by supplying enough soluble N to the microbes
(Devendra, 1976).

For high rates of growth, the demand for amino acids is higher than can be provided by an optimized rumen fermentation and therefore supplements of by-pass protein are essential (Leng and Preston, 1985).

In the absence of a fermentable energy substrate and other exogenous nutrients, about 60% of the rumen bacterial population dies and about 30% or more lyses within 2 hr due to starvation (Hespel, 1979). Devendra (1976) has shown that urea is valuable in stimulating the intake of rice straw and this beneficial response was favored by the presence of soluble carbohydrates (Devendra, 1976). The provision of readily fermentable carbohydrates (RFC) improves the utilization of ammonia for cell growth. Molasses, which is the cheapest source of energy, can be used RFC supplement and it is available in the rift valley as by product of Wonjji and Metehara sugar cane factories.

Supplementation of low quality roughage with molasses urea feeds was tried in some countries. However, practical problems regarding toxicity due to high intake of molasses and urea were noted. Use of these ingredients in the form of block was latter noted to be practical solution for this problem. This study was carried out to see the effect of Molasses Urea Block and concentrate supplementation on growth rate of Arsi Bulls.

## Materials and Methods

The experiment was conducted from March to the end of July, 1996 at Adami Tulu Research Center. The center is 1650 m above sea level and is located 167 Km South of Addis Ababa. The annual rain fall is 700 mm and the mean minimum and maximum temperature are 12.6 $^{0}$c and 26.9 $^{0}$c respectively. The soil type is fine sandy loam and the sand : silt: clay ratio is 34: 38: 18 respectively with the PH of 7.88.

Thirty indigenous Arsi bulls with average age of 24 months (based on dentition) and average live weight of 129 kg were purchased from the surrounding market. They were then randomly allocated to the following five diets:

1. Grazing on natural pasture
2. Grazing plus UMB ad-lib.
3. diet 2 plus 0.5kg of concentrate/head/day.
4. died 2 plus 1 kg of concentrate/head/day.
5. diet 2 plus 2 kg of concentrate/head/day.

All experimental animals were allowed to graze on native grazing pasture for 8 hrs. per day. At night the four treatment groups were supplemented with urea-molasses block ad-libitum and different levels of concentrate mixture. Supplements were offered individually every night.

Urea-molasses blocks were made at the center with the following ingredients :- Molasses 30%, Urea 10%, Wheat bran 25%, cement 15%, Noug cake 10%, Mineral mix. 3% and salt (NaCl) 7%. The concentrate mixture was composed of 70%

Noug cake and 30% Wheat bran.

All experimental animals were fed their respective diet for 21 days of adaptation period and 120 days of experimental period. Animals after grazing they were supplemented individually with their corresponding diet every night. Left-overs were collected every other morning quantities of feed offered and refused were recorded daily. Average daily feed intake per animal and per treatment was calculated every week. Total UMB and concentrate intake per animal was calculated from daily intake. Experimental animals were weighted weekly. Initial and final live-weights were calculated as a mean of three consecutive daily weight taken after depriving animals of water for approximately 16 hrs.

The data was analyzed using MSTAT computer program. Variances were analyzed using one way ANOVA and the means were separated using Dncan's Multiple Range Test. Weight gain was calculated and analyzed by regression

## Results and Discussion

### *Weight gain*

Live weight changes of experimental animals as influenced by diet are shown in Table 1.

All experimental animals gained live weight. The highest live weight gain ($P < 0.05$) was achieved by diet 5. Animals without supplement (diet 1) were inferior ($p < 0.05$) in their growth rate throughout the experimental period. In general there were ($p < 0.05$) differences between treatments in growth trends.

The total weight gain increased with increasing level of supplement. Bulls on treatment 2,3,4,and 5 gained on average 9,12,20,and 25 kg/head more than bulls in treatment 1 (control) respectively. Though There was no significant differences between two successive supplemented groups in their growth rate, animals in treatment 2 ( fed block only ) grew faster ($p < 0.05$) than animals in control groups. Bulls on diet 5, showed the fastest growth rate (575g/day/head) followed by those on diet 4, 3 and 2 (530, 465 and 445 g per head per day respectively throughout the experimental period. Animals on diet 4 and 5 had a similar daily gain, but animals in diet 5 had a higher ($p < 0.05$) daily weight gain than those on diet 1, 2, and 3. A similar result was observed in a trial which was conducted in India in which daily weight gain increased as the level of concentrate increased from 0-70% of the ration (Kunju, 1986). Similarly Sudana and Leng (1986) reported a higher live weight gain in lambs which received UMB and supplemented with cotton seed meal compared to the controls.

### Feed Intake

Total DM intake from supplements increased ($P < 0.05$) as the level of concentrate supplement increased (Table 2). Daily and total UMB intake reduced as the level of concentrate supplement increased from 0-2kg/d/h. In a similar trial which was conducted in India the daily block intake was significantly ($p < 0.05$) reduced as the level of concentrate increased from 0 - 100% of the ration (Kanju,1986). The decrease in UMB intake as level of concentrate supplementation in the diet increased

is basically due to substitution effect.

Table 1. Performance of growing Arsi bulls fed urea-molasses block supplemented with different levels of concentrate.

| Measurement | Diet | | | | | SE |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | |
| Av. init. weight (kg) | 119.2 | 115.9 | 122.7 | 121.2 | 124.9 | 1.54 |
| Av. fin. weight (kg) | 163.4 | 169.8 | 179.1 | 185.3 | 194.4 | 2.97 |
| Av. weight gain (kg) | 44.3 | 53.9 | 56.4 | 64.1 | 69.4 | 2.07 |
| Growth rate (g/d/h) | 396.0 | 468 | 518 | 593 | 612 | 0.02 |
| Supp. intake (g/d/h) | 0.0 | 543 | 857 | 1210 | 1962 | 0.13 |
| UMB intake (g/d/h) | - | 543 | 373 | 250 | 268 | 0.04 |
| Conce. intake (g/d/h) | - | - | 485 | 960 | 1692 | 0.12 |
| Cost of Supp. (Birr/100 kg) | - | 0.39 | 48.0 | 58.8 | 91.1 | 5.92 |
| Supp. cost/gain (Birr/kg gain) | - | 0.8 | 0.9 | 0.9 | 1.1 | 0.08 |

Table 2. Effect of level of concentrate on UMB intake

| | Level of concentrate (kg/h/d) | | | | |
|---|---|---|---|---|---|
| | 0 | 0.5 | 1 | 2 | SE |
| Total supp.intake(kg) | 57.4 | 104.1 | 146.6 | 239.3 | 16.14 |
| Total DMI (Kg) | 54.8 | 89.4 | 127.5 | 208.8 | 13.92 |
| Ave.daily feed intake (g/h/d) | 543 | 857 | 1210 | 1962 | 0.13 |
| Total conce.intake(kg/h) | - | 58.8 | 116.1 | 206.3 | 15.20 |
| Ave. daily con.intake(g/h) | - | 485 | 960 | 1962 | 0.12 |
| Total block intake(kg/h) | 65.7 | 45.2 | 30.5 | 32.9 | 4.52 |
| Ave.daily block intake(g/h) | 543 | 373 | 250 | 268 | 0.04 |
| g DMI/g gain | 1.0 | 1.6 | 1.9 | 3.0 | 0.20 |

Even though the highest gain and the fastest growth rate was observed in diet 5 with the highest level of concentrate supplement; the weight gain per kg of supplement intake was the highest ($p<0.05$) in treatment 2. Accordingly the cost of supplement per kg of gain was lower ($p<0.05$) in treatment 2 than treatment 4 and 5. However, the intake of UMB didn't increase as the level of concentrate increased, rather it significantly reduced as the level of concentrate increased. The highest block intake (543 g/h/d) was observed in treatment 2 (without concentrate). From this result it can be concluded that UMB is potentially rich in its feeding value provided that the intake is improved, and supplementing UMB with concentrate doesn't improve the

feeding value of UMB. With more research, the feeding value of UMB may further be investigated along with any other potential feed resource to supplement in order to support better performances of animals.

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# The Effect of Wheat-clover Seeding Pattern on Wheat and Clover Yield in The Highlands of Bale

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## Abstract

An intercropping experiment was conducted for four seasons between 1992-1994 at Sinana Research Center to assess the effect of Wheat/clover seeding pattern on grain, straw and total biomass production of wheat. Wheat/clover seeding patterns were 1:1, one row wheat/one row clover; 2:1, two row wheat/one row clover; 3:1, three row wheat/one row clover; treatment one mixed in row; treatment two mixed in row; and treatment three mixed in row. Control plots were monocrops of wheat and clover. All the intercropping treatments did not reduce wheat grain yield significantly across seasons compared with wheat in monoculture. Total crop residue yield was significantly higher in the 1:1, 2:1, 3:1 Wheat/clover alternate row patterns and in the 1:1 seed mixture (row basis) compared with the straw yield produced from the sole wheat. Total crop residue, straw, and clover dry matter yield difference between the six intercropping systems, however, was not significant. But the alternate row seeding patterns compared with the mixed in row treatments, had higher amount of clover (10% vs 4%) in the total crop residue, and produced higher total crop residue (20% vs 15%) over the sole wheat. Seeding patterns can, therefore, affect the yield and composition of crop residues in intercropping.

## Introduction

The most widespread cropping system in Africa consists of mixed intercropping in compound farms which forms a complex but stable agro-ecosystem. Traditional farmers practice intercropping for its higher total yields and greater returns than the same crops grown in pure culture. intercropping has several advantages among which efficient utilization of resources by plants of different heights, rooting systems, and nutrient requirements and the benefit from the companion none legume when it is grown with legumes are the major ones (Okgibo and Greenland 1983). In Bale highlands, feed shortage particularly during the dry season is the major constraint to livestock production (Alemayehu and Franzel 1987). In order to alleviate the feed shortage, research has identified some potential forage species for the area (Tekleyohannes and Worku, 1996). However, most farmers in the area are not interested in growing sole stands of forage crops mainly due to the scarcity of cropping land which is usually used for food crop production.

But if forages can be grown in association with food crops which could lead to an increased production of fodder without adversely affecting anticipated grain yields, farmers might be interested in adopting them. The objective of this study was to identify optimum wheat/clover seeding pattern to develop suitable intercropping system for these crops.

## Materials and Methods

The study was undertaken for four seasons between 1992-1994 at Sinana Research Center, 463 km South East of Addis Ababa. The center is located at an altitude of 2400 m. The soil is black clay. The average minimum and maximum temperature and the rainfall records during the trial seasons are shown in Table 1. The design used was randomized complete block with four replicates. Eight intercropping treatments were evaluated in 2 mx 2.4 m plots, of which two were mono cultures of wheat and clover (Table 2). The wheat/clover proportion was determined based on the arrangement of rows and land use in inter cropping. The clover sown was *Trifolium quartinanium (ILCA 7675)*. The bread wheat (*Triticum aestivum L.*) variety used was ET-13. All rows were spaced 20 cm apart. The seeding rate for wheat and clover was 150 and 20 kg/ha, respectively, in pure stands. Their seed rate in intercropping situations was based on their ratio of land use as compared to the seed rate used in monoculture. Fertilizer was applied at the rate of 106/58 NP kg/ha at planting. Sowing and weeding was done as recommended for wheat. The plots were selectively hand weeded leaving the clover in wheat. Clover was harvested immediately after the harvest of wheat. Data on wheat grain, straw, clover dry matter and total crop residue (straw + clover) yield were recorded for analysis.

Table 1. Weather data during the experimental period (1992-1994) at Sinana

| | | 1992 | 1993 | | 1994 | Mean | |
|---|---|---|---|---|---|---|---|
| | | Meher | belg | meher | belg | Meher | belg |
| Air Temp. $^0$C | Min | 9.1 | 9.3 | 6.8 | 9.6 | 8.0 | 9.5 |
| | Max | 20.0 | 20.7 | 21.4 | 21.9 | 20.7 | 21.3 |
| Rain Fall | (mm) | 519.0 | 316.0 | 362.0 | 332.0 | 441.0 | 324.0 |

## Results AND Discussion

All the intercropping treatments did not reduce wheat grain yield significantly compared with wheat grown in pure stand across seasons (Table 2). Total crop residue yield was significantly higher in the 1:1, 2:1, 3:1 wheat/clover alternate row seeding patterns and in the 1:1 wheat/clover seed mixture (row basis) compared with the pure wheat. Straw, clover dry matter, total crop residue yield differences between the six intercropping systems, however, was not significant ($p < 0.05$). But total crop residue increased 20% over the sole wheat by alternate row intercropping and only 15% by

mixed in row intercropping. Abate *et al.* (1995), however, reported a 63 and 210 % increase in total crop residue yield over the sole wheat in wheat/clover mixed cropping experiment at Deneba and Ginchi, respectively. Climate and soil variations may be the reasons for the differences.

Table 2. Average wheat grain, straw, clover dry matter and total crop residue yield (quintal/ha) at Sinana 1992-1994 (four seasons)

| Wheat/legume seeding pattern | Wheat yield | | yield of | |
|---|---|---|---|---|
| | Grain | straw | clover | total crop residue |
| One row wheat/one row clover | 26.2 | 54.2 | 6.9 | 61.1 |
| two row wheat/one row clover | 29.5 | 54.8 | 5.8 | 60.6 |
| three row wheat/one row clover | 31.0 | 57.2 | 4.3 | 58.5 |
| treatment 1 mixed in row | 30.5 | 55.8 | 2.2 | 58.1 |
| treatment 2 mixed in row | 33.5 | 55.8 | 2.0 | 57.8 |
| treatment 3 mixed in row | 31.9 | 55.0 | 2.4 | 57.4 |
| wheat with no clover | 32.6 | 50.3 | - | 50.3 |
| mean row intercropping | 28.9 | 54.4 | 5.7 | 60.1 |
| mean mixed in-row intercropping | 32.0 | 55.5 | 2.2 | 57.8 |
| sole clover | - | - | 36.3 | 36.3 |
| LSD 0.05 | ns | ns | 6.61 | 7.77 |

ns = Non significant

Clover dry matter yield was markedly lower in intercropping than sole cropping (Table 2). This indicates the suppressive effect of wheat on clover. The effect was severe in mixed intercropping than alternate row intercropping as was apparent in the clover constituent in the total crop residue which was 4 % in mixed intercropping and 10 % in the alternate row intercropping. Straw yield, however, was relatively higher in intercropping than sole wheat cropping. This increase in straw yield over the sole wheat, as was also suggested by Abate *et al.* (1995), is probably due to the N fixed by the clover. The quality of wheat residue(straw) in the pure stand and in mixture with clover,however, was not determined in this experiment. But a research done at Ginchi indicated an increase in crude protein content of crop residues from 2.0 % for wheat residues to 7.6 % for wheat-clover residue. An increase in *in vitro* dry matter digestibility from 35 % to 49 % was also reported (Abate *et al.* 1995).

The combined analysis over the four seasons showed a significant difference between the four seasons. Mean wheat grain, straw and total crop residue yield was significantly higher in meher season (July to November) than belg (February to June)

(Table 3 ). This was due to the higher rainfall received in the season compared with the belg season (Table 1).

The study showed that the quantity of crop residues from wheat fields can be increased by intercropping wheat with clovers either in alternate rows or in seed mixture with wheat without affecting the grain yield.

Table 3. Seasonal variation in wheat grain, straw, clover dry matter and total crop residue yield (quintal/ha) at Sinana 1992-1994.

| year | season | wheat yield | | yield of | |
|---|---|---|---|---|---|
| | | grain | straw | clover | total crop residue |
| 1992 | meher | 49.4 | 88.9 | 17.6 | 93.4 |
| 1993 | belg | 20.5 | 43.5 | 1.1 | 49.3 |
| 1993 | meher | 24.8 | 40.5 | 12.9 | 36.4 |
| 1994 | belg | 28.3 | 47.7 | 2.7 | 44.0 |
| mean | meher | 37.1 | 64.7 | 15.2 | 71.4 |
| | belg | 24.4 | 45.6 | 1.9 | 40.2 |
| LSD | 0.05 | 7.99 | 5.53 | 6.78 | 9.80 |

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# A Note On Cost of Seed Production of *Vicia atropurpurea* as Influenced by Different Supporting Structures

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## Abstract

Cost of seed production of *Vicia atropurpurea* as influenced by different supporting structures was carried out in two cropping seasons in the Ethiopian sub-humid environment. Seed yields obtained from the different supporting structures were significantly different. The average seed yield for unsupported, A-frame and fence supported vetch seed crop were 477, 1995 and 3195 kg/ha, respectively. The result of the study consistently showed that the seed yields of *Vicia atropurpurea* could be increased by more than 318% and 570% over the control (unsupported) plots when *Vicia atropurpurea* was supported by a structure constructed in the form of A-frame and fence, respectively. A-frame supporting required the highest labour input of 4231 hours/ha. This particular structure with a total variable cost of 3653 Birr/ha, gave the lowest net benefit of -261 Birr/ha. However, fence supporting required lesser total variable cost than A-frame and gave the highest net benefit of 2802 Birr/ha. From the stand point of both seed yield and net return advantages, the provision of supporting structure constructed in the form of a fence is recommended for *Vicia atropurpurea* seed production in the sub humid environment.

## Introduction

The rapid increase in small scale feed lots and dairying in and around urban centres and sever livestock feed shortages that came as a consequence of shrinking grazing lands in agriculturally potential areas have created a pasture seed demand never experienced in Ethiopia before. Wider use of pasture crops by small holder farmers and the farming community at large, however, have been hampered by inadequate seed supply and lack of economic and practicable seed production packages. First attempt to produce cultivated pasture crop seeds by small holder farmers on contractual basis in selected regions of Ethiopia has shown some success (Alemayehu, 1994). Vetches were among the pasture crop species grown by small holder farmers in seed production schemes and of course are in wider use in small and large scale feedlots and dairy programs at a significant level. Other than livestock feed, in the highlands of Ethiopia vetch green manuring resulted in increased barley grain yield and soil N, $P_2O_5$ and K (Balesh, 1989). Under farmers management, seed yield from flat (unsupported) planted vetch, however, are very low and rarely exceeds 300 kg/ha. In the absence of supporting structure, the weak stemmed vetch crop lay one over the other thus denying those underneath from sun light exposure.

Provision of supporting structures for twining and climbing pasture species have been noted to improve seed yield of some tropical pasture species (Humphreys and Riveros, 1986). It is therefore felt important to employ an appropriate cultural practice that exploits the natural climbing habit of vetch that possibly improves the present low level of seed yield per unit area. This study, therefore, was undertaken to determine the effects of different supporting structures on seed yield and production cost of *Vicia atropurpurea*.

## Materials and Methods

***Experimental site***. The study was carried out at Bako Research Centre, located at 9°6' N latitude, 37°09' longitude and 1650 m asl. The mean annual rainfall is 1200 mm, of which more than 80% is received between May and September. The soil is reddish brown clay to sandy clay loam, with average $P^H$ of 5.3.

***Design and layout of the trial***. The three methods of vetch seed production tested in this study were: no support (control), supporting structures in the form of A-frame and fence. Plots measuring 100 $m^2$ (10 m * 10 m) and separated by 1.5 m were marked out in randomized complete block design. Wooden supporting structures (A-frames and fences) were constructed from locally available young trees of narrow diameter and sisal string.

An inter row spacing of 30 cm was used for unsupported plots.

A-frames were set 1.2 m apart. The base of the A-frame was 0.8 m wide and rows were made 10 cm away from the inner and outer sides of the A-frame base. Fences were erected 1.5 m apart and rows were made 10 cm away from either sides of the fence.

***Trial management.*** Diammonium phosphate (DAP) fertilizer at the rate of 200, 125 and 87.5 kg/ha were row applied for plots with out physical structure, plots with A-frame and fence structures, respectively. Likewise, 20, 12.5, and 8.8 kg seeds/ha were sown on unsupported, A-frame and fence supported plots. Plots were kept free of weeds by hand weeding. At physiological maturity, vines were up-rooted and stocked for few days and threshed by beating with a stick.

***Data analysis***. Analysis of variance was conducted on clean seed yield that adjusted to 12.5% moisture content. Least significant difference (LSD) was employed to separate the means. For economic analysis vetch seed yield was adjusted down ward by 15% to account for the difference that might exist between yields from experimental plots and production field. Both input and out puts were valued at their respective market prices. Field prices were not used because forage crops seed production and marketing systems in Ethiopia when this experiment was conducted were at an infant stage. As a result, it was very difficult to define the field prices for inputs and outputs considered in this study. The market price of vetch was 2 Birr/kg (price paid by the Fourth Livestock Development Project to the farmers), fertilizer price was 150 Birr/100kg for DAP, and pole price was 0.5 Birr/pole. The official wage rate was 1.95 Birr/man day (one man day being equivalent to 8 hours work of a person).

## Result and Discussion

The respective seed yields for unsupported, A-frame and fence supported structures were 477, 1995 and 3195 kg/ha respectively. Supporting the vetch seed crop with physical structures significantly ($P < 0.01$) improved seed yield. Similar positive effects were noted for *Macroptilium atropurpureum, Macrotyloma axillare* and *Galactia striata* seed crops that have been provided with supporting structures (Humpherys and Riveros, 1986). In the present study, seed yields in A-frame supported plots were lower than ($p < 0.05$) the fence supported counterpart mainly due to poor light penetration into the inner parts of the A-frame.

All the different methods had got the same machinery inputs; about 5 hours of machinery power per hectare was used for land preparation (ploughing and twice discing). However, labour and material inputs needed were variable for the different operations. A-frame supporting required the highest labour input and with the highest total cost (Table 1) hence the lowest net benefit (Table 2). Fence supporting gave the highest net benefit of 2802 Birr/ha. Vetch seed production with out provision of supporting structure and A-frame support were not economically at loss and feasible and they are not recommended. From fence supporting, the return to the total cost was 112%, which is above the minimum acceptable rate of return (100%). Therefore, this form of supporting structure is economically the best and recommended using the partial budget approach.

Table 1. Labour and material inputs using different supporting methods of vetch seed production (Average of 1992 and 1993)

| | Types of supporting structures | | |
|---|---|---|---|
| Inputs | Unsupported | A-frame | Fence |
| Labour (hrs./ha) | | | |
| Constructing | 0.00 | 1758.00 | 1235.50 |
| Planting[1] | 330.50 | 213.50 | 149.50 |
| Weeding | 1434.75 | 1289.75 | 1162.00 |
| Harvesting & threshing | 839.75 | 969.75 | 845.25 |
| Total | 2605.00 | 4231.00 | 3392.25 |
| Material inputs | | | |
| Fertilizer, DAP (kg/ha) | 200.00 | 125.00 | 87.50 |
| Seed (kg/ha) | 20.00 | 12.50 | 8.75 |
| Pole (No./ha) | 0.00 | 5000.00 | 3200.00 |

[1] Planting includes row making, fertilizer application and seed drilling.

Table 2. Partial budget for *Vicia atropurpurea* seed production using different support methods

| Item | Types of supporting structures | | |
|---|---|---|---|
| | Unsupported | A-frame | Fence |
| Average seed yield (kg/ha) | 477.00 | 1995.00 | 3195.00 |
| Adjusted seed yield (kg/ha) | 405.50 | 1695.80 | 2656.30 |
| Gross field benefits (Birr/ha) | 811.00 | 3391.60 | 5312.60 |
| Variable cost (Birr/ha) | | | |
| a) Labour cost | | | |
| Fencing | 0.00 | 421.92 | 296.52 |
| Planting | 79.32 | 51.24 | 35.88 |
| Weeding | 344.34 | 309.54 | 278.88 |
| Harvesting & threshing | 201.54 | 232.74 | 202.86 |
| Sub total | 625.20 | 1015.44 | 814.14 |
| b) Material cost | | | |
| Fertilizer | 180.00 | 112.50 | 78.75 |
| Seed | 40.00 | 25.00 | 17.50 |
| Pole | 0.00 | 2500.00 | 1600.00 |
| Sub total | 220.00 | 2637.50 | 1696.25 |
| Total variable cost (Birr/ha) | 845.20 | 3652.94 | 2510.39 |
| Net benefit (Birr/ha) | -34.20 | -261.30 | 2802.21 |

In the mixed farming systems zone of Bako, supporting climbing beans with wooden post is a well established practice. At farm level, sufficient wooden poles can also be produced from fast growing multipurpose trees such as *Susbania susban* that commonly grow around homestead and field boundaries. Despite the higher potential of *Vicia atropurpurea* for green manuring, animal feed and erosion control, its production by farmers has not been expanded as desired due to low seed yield and high cost of seed production. From the present work, supporting vetch seed crop with a structure constructed in the form of a fence was found to be biologically superior and economically profitable.

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